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THE RADIO AMATEUR NEWCOMER

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Foreword

In this, the first postwar edition of THE RADIO AMATEUR NEWCOMER, it has been the plan of the editors to provide in a single book sufficient information to enable a newcomer to the field of amateur radio to accomplish the following things without the aid of outside study material: (1) Obtain sufficient background and knowledge in the field of amateur communication to enable the newcomer to pass successfully the FCC examination for an Amateur Radio Operator License. (2) Build an inexpensive but troublefree amateur radio station after the Amateur Radio Station License has been obtained from the FCC. (3) Operate his amateur radio station in an intelligent manner and in accordance with existing operating procedures.

In preparing for the FCC examination the entire book should be studied first, from cover to cover, briefly to obtain a general idea of the field of amateur radio and of the tools used. After this, Chapter 4 should be studied in some detail and the project of learning the radio code started. As the code speed improves, Chapters 2, 3, 10 and 11 should be studied in considerable detail. After the code speed has improved to 15 or 16 words per minute and each of the questions in Chapters 10 and 11 can be answered without reference to the book, the other chapters in the book should be skimmed once more.

On the eventful day of going before the local FCC office for the amateur examination, try and be relaxed and at ease with the world. By far the largest number of failures among those taking the FCC license examination are due to inability to attain perfect copy of 65 consecutive characters in the code reception test. And the largest number of these failures are due to excessive nervousness on the part of the person taking the examination. After the examinations in sending and receiving the code have been passed the written portion of the examination should be handled without much difficulty.

EDITORS AND ENGINEERS, LTD.
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CHAPTER ONE

Introduction To Amateur Radio

The hobby of amateur radio hardly needs an introduction. Today, there are few towns with no amateur radio stations at all, and undoubtedly there are still fewer towns where amateur stations have never been heard. No laboratory type radio set is needed in order to hear the amateurs. If you tune across the dial of the all-wave radio in your own living room any night, you will hear them communicating with each other.

You have come in contact with this hobby in some way and your interest has been aroused; otherwise you would not have obtained this book.

The radio amateur (he also calls himself a *ham*) participates in *two-way* radio as a hobby. His station is an educational plaything. With him, this activity is an avocation. He might send a radiogram for himself or somebody else, but he does this just for fun and practice. The Government, which gives him a license, does not allow him to accept remuneration in any form. Nor is the amateur permitted to send out news, music, lectures, or any other program addressed to the general public. Only broadcast stations are allowed to do that. The term *amateur* thus defines his non-commercial status. It does not imply that the amateur radio operator is not proficient. Quite to the contrary, many radio amateurs are electronics engineers, professional radio operators, or electrical technicians by vocation.

Two-way amateur contacts may be local or distant. On any day of the week, you can find hams in your own town talking with others in foreign countries, often with the same ease with which they "raise" their local associates. The number of ham contacts between distant stations exceeds the number of local conversations on the air.

Amateur radio is an absorbing hobby. It allows an escape from the humdrum affairs of the day. Because of its scientific nature, it captures complete attention and challenges the imagination. In these respects, it is the perfect hobby. Its adherents will tell you that no other indoor sport can offer the same allure. The unusual fascination of ham radio lies in the opportunity it affords to converse with thousands of other radio hobbyists all over the world while seated comfortably at home.

Amateur radio doubtless is as old as the art of radio communication itself. It seems likely that electrical-minded individuals set up and used two-way radio sets as soon as technical radio information began to appear in print in the early 1900's, and perhaps even before radio books and articles appeared. We have no accurate record of these beginnings. The United States began licensing amateur transmitting stations in 1912. However, hundreds of such stations already were on the air before the license law went into effect, and a small number of U. S. amateurs who were in that group still are active in the hobby.

Who May Be a Radio Amateur

Radio hams are men and women, boys and girls of every age and nation-

ality. There are no restrictions as to age, race, sex, or nationality. The daily occupations of the people who pursue this hobby are as diverse as their backgrounds. Included in the ranks of amateur radio are members of each of the professions, business men, executives, clerks, technicians, laborers, mechanics, students, and housewives. There even is a "shut-in" or "chair warmer's" club composed of invalid hams. Some of the latter are blind and have learned radio by reading Braille books on the subject. Any person able to qualify for the necessary licenses can become a ham.

Radio amateurs are distributed throughout the world. In the United States alone, there are more than 60,000 licensed amateur stations. This is more than will be found in all the rest of the world. The number steadily is growing.

Amateur Call Letters

Amateur stations may be distinguished from other stations on the air by means of their distinctive call letters. An example is W1ABC. In the United States, the only other class of station having this same arrangement of letters and numerals is the experimental station. However, in experimental station call letters, the letter X always follows the numeral. The letter X never is employed right after the numeral in amateur call letters.

The letter or letters before the numeral designates the country in which the station is located and is called the *international prefix*. The letter W, for example, is the international prefix for the United States. The call letters of all U. S. amateur stations therefore start with the letter W. When all "W" call letters have been used up, it is proposed that the prefix K will be used in the United States. Table 1 on pages 7 and 8 lists all of the international prefixes used throughout the world.

The numeral in amateur call letters usually designates the area in which the station is located within the licensing country. The numeral 1, for example, indicates that a U. S. amateur station is located somewhere in the New England area. Table 1 shows that in several instances the numeral is a part of the international prefix of certain foreign call letters. The call areas of the United States and their designating numerals are given in Table 2 on page 15.

Following the numeral are two, or three letters which individualize the station. Thus, every California amateur station is assigned the first two characters *W6*, but there is only one W6AAA.

Amateur call letters are worked out by the Government radio licensing authorities. In the United States, requests for special amateur call letters are not granted. Instances of a station owner's initials, or some other distinctive combination of letters, appearing after the numeral in his call letters may be explained either as a coincidence or as a case of his having obtained a special set of call letters long ago when special requests were honored.

Because of the limited number of possible 2-letter combinations, these call letters (such as W9AB) were exhausted several years ago. Most amateur call letters in the United States accordingly have three letters after the numeral. Two-letter calls are now issued only to applicants who have at one time held a two-letter call.

Amateur Radio Licenses

You will need two licenses in order to engage in amateur radio. Your *amateur radio operator license* must be obtained by examination, and your *amateur radio station license* by application.

TABLE 1

AMATEUR CALL SIGN PREFIXES

The following prefixes identify the location of the amateur station being heard.

AC3 .....Sikkim
AC4 .....Tibet
AR .....Syria
C .....China
CE .....Chile
CM, CO .....Cuba
CN .....French Morocco
CP .....Bolivia
CR4 ....Cape Verde Islands
CR5 .....Portuguese Guinea
CR6 .....Portuguese Angola
CR7 .....Mozambique
CR8 .....Portuguese India
CR9 .....Macao
CR10 .....Timor
CT .....Portugal
CT2 .....Azores
CT3 .....Madeira Islands
CX .....Uruguay
D .....Germany
EA1, 2, 3, 4, 5, 7 .....Spain
EA6 .....Balearic Islands
EA8 .....Canary Islands
EA9 .....Spanish Morocco
EI .....Ireland
EK .....Tangier
EL .....Liberia
EP, EQ .....Iran (Persia)
ES .....Estonia
ET .....Ethiopia
F3, 8 .....France
FA .....Algeria
FB8 .....Madagascar
FD8 .....French Togoland
FE8 .....French Cameroons
FF8 ....French West Africa
FG8 .....Guadeloupe
FI8 .....French Indo-China
FK8 .....New Caledonia
FL8 .....French Somaliland
FM8 .....Martinique
FN8 .....French India
FO8 .....French Oceania
FP8 .....St. Pierre and Miquelon Islands
FQ8. French Equatorial Africa
FR8 .....Reunion Island
FT4 .....Tunisia
FU8 .....New Hebrides
FY8 ...French Guiana & Inini
G .....England
GC .....Channel Islands
GI .....Northern Ireland
GM .....Scotland
GW .....Wales
HA .....Hungary
HB .....Switzerland
HC .....Ecuador
HE1 .....Liechtenstein
HH .....Haiti
HI .....Dominican Republic
HJ, HK .....Colombia
HP .....Panama
HR .....Honduras
HS .....Thailand (Siam)
HZ .....Saudi Arabia
I .....Italy
I6 .....Eritrea
J .....Japan
J8 .....Korea
J9 .....Okinawa
K .....Continental U.S.
KA .....Philippine Islands
KB6 ....Baker, Howland and Phoenix Islands
KC4 .....Little America, Antartica
KG6 .....Guam
KH6 .....Hawaii
KJ6 .....Johnston Island
KL7 .....Alaska
KM6 .....Midway Islands
KP4 .....Puerto Rico
KP6 ..Palmyra and Jarvis Isls.
KS4 .....Swan Island
KS6 .....American Samoa
KV4 .....Virgin Islands
KW6 .....Wake Island
KZ5 .....Canal Zone
LA .....Norway
LI .....Libya
LU .....Argentina
LX .....Luxembourg
LY .....Lithuania
LZ .....Bulgaria
MX .....Manchuria
NY4 ..Guantamo Bay, Cuba
OA .....Peru
OE .....Austria
OH .....Finland
OK .....Czechoslovakia
ON .....Belgium
OQ .....Belgian Congo
OX .....Greenland
OY .....Faeroes Islands
OZ .....Denmark
PA, PI .....Netherlands
PJ .....Curacao

PK1, 2, 3 .....Java
PK4 .....Sumatra
PK5 .....Borneo
PK6...Celebes, Molucca and Dutch New Guinea
PX .....Andorra
PY .....Brazil
PZ..Surinam (Dutch Guiana)
SM .....Sweden
SP .....Poland
ST .....Sudan
SU .....Egypt
SV, SX .....Greece
SV5 ....Dodecanese Islands
TA .....Turkey
TF .....Iceland
TG .....Guatemala
TI .....Costa Rica
UA1 to 7 ..European Russia
UA8 to 0 ....Asiatic Russia
UB .....Russian Ukraine
UC .....White Russia
UD6 .....Azerbaijan
UF6 .....Georgia
UG6 .....Armenia
UH8 .....Turkoman
UI8 .....Uzbek
UJ8 .....Tadzhik
UL7 .....Kazakh
UM8 .....Kirghiz
UN1 .....Karelo
UO5 .....Moldavia
UP .....Lithuania
UQ .....Latvia
UR .....Estonia
VE .....Canada
VK2, 3, 5, 6, 8 ....Australia
VK4 .....Papua Territory
VK7 .....Tasmania
VK9.Territory of New Guinea
VO .....Labrador and Newfoundland
VP1 .....British Honduras
VP2..British Windward and Leeward Islands
VP3 .....British Guiana
VP4....Tobago and Trinidad
VP5..Cayman, Turks, Caicos and Jamaica Islands
VP6 .....Barbados
VP7 .....Bahamas
VP8 .....Falkland Islands
VP9 .....Bermuda
VQ1 .....Zanzibar
VQ2 .....Northern Rhodesia
VQ3 .....Tanganyika
VQ4 .....Kenya
VQ5 .....Uganda
VQ6 .....British Somaliland
VQ8...Mauritius and Chagos
VQ9 .....Seychelles
VR1 .....Gilbert and Ellice Islands and Ocean Island
VR2 .....Fiji Islands
VR3 .....Fanning Island
VR4 .....Solomon Islands
VR5 .....Tonga Island
VR6 .....Pitcairn Island
VS1 ....Strait Settlements
VS2.Federated Malay States
VS3 ...Non-federated Malay States
VS4....British North Borneo
VS5....Sarawak and Brunei
VS6 .....Hong Kong
VS7 .....Ceylon
VS8 .....Bahrein Island
VS9 .....Maldive Islands
VU .....India
VU4 .....Laccadive Island
VU7 .....Bahrein
W .....Continental U.S.
XE .....Mexico
XU .....China
XZ .....Burma
YA .....Afghanistan
YI .....Iraq
YJ .....New Hebrides
YL .....Latvia
YM .....Danzig
YN .....Nicaragua
YR .....Roumania
YS .....Salvador
YT, YU .....Yugoslavia
YV .....Venezuela
ZA .....Albania
ZB1 .....Malta
ZB2 .....Gibraltar
ZC1 .....Transjordania
ZC2 .....Cocos Island
ZC3 .....Christmas Island
ZC4 .....Cyprus
ZC6 .....Palestine
ZD1 .....Sierra Leone
ZD2 .....Nigeria
ZD3 .....Gambia
ZD4 .....British Togoland
ZD6 .....Nyasaland
ZD7 .....St. Helena
ZD8 .....Ascension Island
ZD9 .....Tristan da Cunha
ZE6 .....Southern Rhodesia
ZK1 .....Cook Islands
ZK2 .....Niue
ZL .....New Zealand
ZM .....British Samoa
ZP .....Paraguay
ZS1, 2..Union of South Africa
ZS4, 5, 6 .....South Africa
ZS3 .....Southwest Africa

The station license is granted only to a licensed operator. Both are essential and it is just as unlawful to operate a transmitting station without *both* as to drive an automobile without both a driver's license and a state license plate. Unlawful operation is a Federal offense and is punishable by fine, imprisonment, or both.

In the United States, the Federal Communications Commission (F.C.C.) conducts examinations for amateur radio operator licenses at various district offices throughout the Country. A list of these places is given on pages 16, 17 and 18. Your application blanks (Form 610) should be obtained from the nearest district office, at which you also will be required to appear for your examination.

There is only one class of amateur station license. However, there are three classes of amateur operator license. These will be described separately.

Class A. The examination for this license may be taken only by a U. S. citizen who has held for at least 1 year an amateur operator license issued by the F.C.C. and who passes an additional examination. If the applicant has held a class B amateur operator license, the examination will consist of a written test on advanced amateur telephony. If, instead, he has held a class C amateur operator license, he must take both the class A and class B examinations in their entirety. The class A license entitles its holder to full use of all amateur frequencies.

Class B. Any U. S. citizen may take the examination for the class B amateur radio operator license. The written portion of this examination consists of questions on (1) radio theory, transmitters, receivers, and other station equipment; and (2) accepted station operating procedures and Government regulations pertaining to amateur radio. You may be required to draw several radio circuit diagrams. A minimum grade of 74% must be made in order to pass the written examination.

The practical portion of the class B examination consists of sending and receiving the International Morse code at a speed of not less than 13 words per minute. In order to pass the code test, you must send and receive without error for a continuous period of 1 minute in the 5-minute test period. Plain language is used and words are counted as 5 characters each. Each numeral or punctuation mark counts as 2 characters.

The class B operator license entitles its holder to the use of all amateur frequencies except certain radiotelephone bands reserved for class A licensees. These special bands will be mentioned under *Amateur Frequencies and Wavelengths.*

As a newcomer, if you live within 125 miles airline of a city or town in which amateur examinations are held, you will apply for the class B license.

Class C. The examination for a class C amateur operator license is the same as that for class B, except that the applicant does not appear at the Government office for the test.

The class C examination may be taken only by a U. S. citizen who lives more than 125 miles airline from the nearest place where class B examinations are held at least once each 3 months, or who can show by a physician's certificate that protracted disability prevents his appearance at the examination place, or who can show by a commanding officer's certificate that he is unable to appear because he is serving as a member of the U. S. armed forces at a military, naval, or Coast Guard station.

The class C examination will be conducted in your home town by not more than two volunteer examiners. These examiners may be designated by the Commission or selected by you. In either case, the examiner who conducts the code test must be the holder of a class A or class B amateur operator license; or, in lieu of this, he either must have held, within the 5 years prior to the date of the examination, a commercial radiotelegraph operator's license issued by the F.C.C. or must have been employed in the service of the United States as the operator of a *manually operated* radiotelegraph station. The examiner who conducts the written test must be at least 21 years old.

As the holder of a class C amateur operator license, you will have the same privileges as the holder of a class B license.

The commission may at any time require the holder of a class C license to appear for a class B examination. If the licensee fails to appear or fails to pass the examination, the class C license will be cancelled.

If you fail to pass your examination for an amateur operator license, you may not take another examination in less than 30 days. However, you may take the class B examination in less than 30 days if you have failed a class C examination.

Your amateur operator and station licenses each will be valid for a period of 5 years from the date of their issuance, renewal, or modification.

How Amateurs Communicate Telegraphy and voice are the two mediums of communication normally employed by radio amateurs. Each method has its group of staunch adherents, and a number of hams use both. Far more amateurs employ the telegraph code (in a method known in radio circles as *c-w telegraphy)* than voice *(radiotelephony,* or just plain *'phone).* For that reason, more space is allowed on the air for amateur radiotelegraphy than for radiotelephony.

An exceedingly small number of hams have made use of television and facsimile (transmission and reception of written and printed matter), systems which are authorized on certain amateur frequencies.

Frequency modulation (FM) is employed by amateurs for voice communication, and may be used also for certain forms of telegraphy. But, up to the time of this writing, amateurs have not made wide use of FM for voice and little interest has been shown in FM telegraphy. However, increased use of FM for voice communication is appearing on the amateur bands above 27.185 Mc.

Radio telegraphy is much more dependable than voice for communication over long distances or under adverse conditions, such as heavy interference from other stations or from static. Only a fraction as much power is required in order to communicate under given conditions, and no audio frequency equipment is required. It accordingly offers the amateur the most for his investment in transmitter equipment and electric power. These undoubtedly are the reasons for its continued popularity in spite of the slowness of telegraphy when compared with the spoken word.

Amateur Frequencies and Wavelengths In order to prevent hopeless confusion on the air, the governments of the world have agreed to assign definite frequencies or wavelengths to each class of radio station. In order to provide for the large number of amateur sta-

tions, frequencies have been assigned to this service in "bands" a specified number of kilocycles in width. A licensed amateur may select any frequency upon which to operate his transmitter, as long as that frequency lies within the proper portion of one of the authorized amateur bands. If he finds other stations operating upon his selected frequency and interfering with his transmissions, he may change to a clearer frequency—keeping always within the lawful limits of the band. For example, if operating c-w he might shift from 3600 kc. to 3750 kc. or to 3825 kc. and still be well within the 3500-4000-kc. amateur band.

Portions of some amateur bands, as will be shown, are allocated for radiotelephone use, portions of other bands for FM, etc. Class B and class C licensees are not permitted to operate a radiotelephone in certain bands which are reserved for "class A" operation.

At the time of this writing, the F. C. C. is restoring amateur bands after the World War II shutdown. Following is a list of all amateur bands authorized in the United States up to this time. It is very likely that these bands will undergo further alteration.

(1) 3500-4000 kc. (85.71-75 meters)
A1, entire band
A3, CLASS-A LICENSEES ONLY, 3850-4000 kc. (77.9-75 meters)

(2) 7000-7300 kc. (42.86-41.09 meters)
A1, entire band

(3) 14,000-14,400 kc. 21.43-20.83 meters)
A1, entire band
A3, CLASS A LICENSEES ONLY, 14,200-14,300 kc. (21.13-20.98 meters)

(4) 27.185 - 27.455 Mc. (11.04-10.92 meters)
Ao, A1, A2, A3, A4, and FM, entire band

(5) 28.0-29.7 Mc. 10.71-10.10 meters)
A1, entire band
A3, 28.5-29.7 Mc. (10.53-10.10 meters)
FM, 29.0-29.7 Mc. (10.34-10.10 meters)

(6) 50.0-54.0 Mc. (6-5.555 meters)
A1, A2, A3, A4, entire band
FM, 52.5-54.0 Mc. (5.714-5.555 meters)

(7) 144-148 Mc. (2.08-2.03 meters)
Ao, A1, A2, A3, A4, and FM, entire band
(Portion between 146.5 and 148 Mc. may not be used by amateur stations within 50 miles of Washington, D. C.; Seattle, Wash.; or Honolulu, T. H.)

(8) 235-240 Mc. (1.28-1.25 meters)
Ao, A1, A2, A3, A4, and FM, entire band

(9) 420-430 Mc. (71.5-69.76 centimeters)
Ao, A1, A2, A3, A4, A5, and FM, entire band
(In this band, peak antenna power must not exceed 50 watts)

(10) 1215-1295 Mc. (24.69-23.17 centimeters)
Ao, A1, A2, A3, A4, A5, FM, and Pulse modulation, entire band

(11) 2300-2450 Mc. (13.05-12.25 centimeters)
Ao, A1, A2, A3, A4, A5, FM, and Pulse Modulation, entire band

(12) 3300-3500 Mc. (9.09-8.57 centimeters)
Ao, A1, A2, A3, A4, A5, FM, and Pulse Modulation, entire band

(13) 5650-5850 Mc. (5.32-5.13 centimeters)

A0, A1, A2, A3, A4, A5, FM, and Pulse Modulation, entire band

(14) 10,000-10,500 Mc. (3-2.86 centimeters)
A0, A1, A2, A3, A4, A5, FM, and Pulse Modulation, entire band

(15) 21,000-22,000 Mc. (1.429-1.362 centimeters)
A0, A1, A2, A3, A4, A5, FM, and Pulse Modulation, entire band

(16) Any frequency above 30,000 Mc. (wavelength shorter than 1 centimeter)
A0, A1, A2, A3, A4, A5, FM, and Pulse Modulation

Bands 1 to 5 are termed *high frequency;* bands 6, 7, and 8, *very high frequency;* bands 9, 10, and 11, *ultra high frequency;* and bands 12, 13, 14, and 15, *super high frequency.*

1. Continuous waves:

Type A0.—Waves the successive oscillations of which are identical under fixed conditions.[1]

Type A1.—Telegraphy on pure continuous waves. A continuous wave which is keyed according to a telegraph code.

Type A2.—Modulated telegraphy. A carrier wave modulated at one or more audible frequencies, the audible frequency or frequencies or their combination with the carrier wave being keyed according to a telegraph code.

Type A3.—Telephony. Waves resulting from the modulation of a carrier wave by frequencies corresponding to the voice, to music, or to other sounds.

Type A4.—Facsimile. Waves resulting from the modulation of a carrier wave by frequencies produced at the time of the scanning of a fixed image with a view to its reproduction in a permanent form.

Type A5.—Television. Waves resulting from the modulation of a carrier wave by frequencies produced at the time of the scanning of fixed or moving objects.[2]

2. Damped waves:

Type B.—Waves composed of successive series of oscillations the amplitude of which, after attaining maximum, decreases.

Note.—Type B waves are not permitted in amateur transmitters due to their bandwidth.

Amateur Transmitter Power Amateur transmitters are limited to a power *input* of 1000 watts (1 kilowatt). This is the input power delivered to the plate circuit of the antenna stage of the transmitter.

An exception to this rule is the 420-430-Mc. band in which the maximum permissible peak antenna power is, at the time of this writing, only 50 watts.

1 These waves are used only in special cases, such as standard frequency emissions.

2 "Objects" is used here in the optical sense of the word.

Amateur Station Equipment An amateur station consists principally of a transmitter and receiver. The same antenna usually is employed for both sending and receiving by utilizing a switch or relay. Government regulations require the amateur to have a *frequency meter* for measuring transmitter frequency, and, if he employs radiotelephony, a *modulation monitor* of some sort.

Any or all of the units of an amateur station may be constructed by the operator or may be purchased factory-built. They also are available in kit form, which simplifies home construction. Directions are given in this book for the building of station equipment suitable for the amateur newcomer. More advanced apparatus is described in the *Radio Handbook* by the same publishers.

Amateur Station Cost As is true of any item, the cost of an amateur station will depend upon the tastes, requirements, and demands of the owner. Factory-built transmitters, receivers, and test instruments may be bought at various prices ranging from less than 100 dollars up to several thousand dollars for a complete station.

The total cost of a home-built station will vary in the same manner. However, except possibly for the receiver, home-built station units generally will cost somewhat less than factory-built units with the same electrical ratings. The simplest possible low-powered station, for code transmission only, may be built completely for 50 dollars or less, depending upon the quality of parts used. If voice communication is desired in addition to telegraphy, this price will be increased considerably.

An outfit of this sort will suffice as a first station for the newcomer who does not care to make a large investment in radio equipment. Given a clear spot on the air, a station of this sort can give a good account of itself in long-distance two-way contacts. But the congestion in most amateur bands due to the large number of stations on the air will, as a rule, reduce the effectiveness of a low-powered outfit, especially on voice transmissions.

Portable Amateur Stations Ordinarily, an amateur station is installed and operated at one permanent address. However, if necessary regulations are complied with, the station may be moved also to other *fixed* locations within the call area in which it has been licensed, or even to other call areas, and operated from those locations. This is called *portable* operation if the station is not operated while in actual transit but only after the moving process has been completed. Portable operation is allowed on any authorized amateur frequency.

An amateur station also may be operated while in motion. This is called *mobile* operation. Examples of mobile stations are those installed in automobiles, boats, or aircraft or carried by hand. Amateur mobile operation is permitted only on authorized amateur frequencies higher than 25 megacycles.

Special Interests of Amateurs Amateur radio has been referred to by some authors as a collection of hobbies within a hobby. This impression has arisen from the several distinct turns taken by amateur interest.

There are operators who revel in long-distance contacts and have little time for any other. They are called

DX men. (DX is a radiotelegraph abbreviation for *distance*). These fellows have as a goal the completion of two-way contacts with every continent and, having achieved that success, to talk with every country in which other hams are located.

Then, there are the operators who favor best a good long chat and to whom a local contact is just as good as one reaching over a thousand miles. They call themselves *rag chewers* and they have an informal international "club."

Message handling is the chief interest of another group. These operators take messages from anyone in their communities and send them as cost-free radiograms to their destinations. They will deliver a reply radiogram on the same free basis. Some of the message handlers have organized chains of relay stations that almost rival the commercial telegraph and radio companies in efficiency. Occasionally, they have beaten the commercial people in "getting through" during storms and disaster.

Another important group is composed of the experimenters. These are the individuals who forever are tinkering with their apparatus. From their modest workshops and laboratories have come some of the noteworthy improvements in radio apparatus.

The experimenter delights in clever improvements. He likes to make radio instruments operate as nearly perfect as possible. To him, getting on the air is only incidental. The air is his proving ground; and you may be sure that he is sending out signals mainly to check the performance of his newly-developed transmitter or circuit or antenna. Personal contacts, as such, are secondary.

A few amateurs distribute their interests and divide their time, thus taking advantage of all that amateur radio has to offer. They experiment, handle messages, rag chew, and make dx contacts. While this sort of participation is strongly recommended to the newcomer, we must observe that the present number of amateurs who have availed themselves of this maximum enjoyment of their hobby is relatively small. In most cases the newcomer eventually will find that one or two phases hold more fascination and he will then concentrate on these.

Civic and Military Importance of Amateur Radio Amateur radio is a vast technical training school which does not call upon public funds or private endowment, as we ordinarily understand the latter term, for its support. From the ranks of ham radio came thousands of ready-trained radio men for the armed forces of the two world wars. From these ranks also have come many of the engineers and technicians of the radio industry. The amateur is a good citizen. He pursues a wholesome hobby which keeps him "about his own business."

In addition to maintaining regular networks of his stations for the relaying of free radiograms, the radio amateur participates during peacetime in army and navy communication networks. In this way, he obtains invaluable training in the communications procedures employed by the armed forces. Numerous members of these communications networks have advanced to reserve commissions in the armed forces.

Through the building and improving of his stations, the radio amateur has become an important customer of the radio industry. His magazines and books make him a respected patron of the printing industry.

The great civic importance of amateur stations is best realized during times of public emergency. When storms, earthquakes, and other natural disasters have wrecked telephone and telegraph facilities, amateur radio often has been the only available means of communication between a stricken community and the outside world. And the amateur is proud, justifiably so, of his record of public service during such harrowing events as the New England and Florida hurricanes, the Mississippi floods, the northwest and middle west sleet storms, the California earthquakes, and many others. Amateur radio has accompanied several expeditions to distant parts of the world, such as the north and south poles, the interior of Africa, and the South American jungles.

TABLE 2

RADIO CALL SIGN AREAS

1—Connecticut, Main, Massachusetts, New Hampshire, Rhode Island, Vermont

2—New Jersey, New York

3—Delaware, District of Columbia, Maryland, Pennsylvania

4—Alabama, Florida, Georgia, Kentucky, North Carolina, Puerto Rico, South Carolina, Tennessee, Virgin Islands, Virginia

5—Arkansas, Louisiana, Mississippi, New Mexico, Oklahoma, Texas

6—California, Hawaii and Pacific Possessions except those lying in the seventh call area

7—Arizona, Alaska and adjacent islands, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming

8—Michigan, Ohio, West Virginia

9—Illinois, Indiana, Wisconsin

0—Colorado, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota

TABLE 3
RADIO DISTRICTS

Radio District	Address of the Inspector in Charge	Territory Within District	
		States, etc.	Counties
1	Seventh Floor Customhouse, Boston 9, Mass.	Connecticut	All counties
		Maine	do
		Massachusetts	do
		New Hampshire	do
		Rhode Island	do
		Vermont	do
2	748 Federal Building 641 Washington Street New York 14, New York	New Jersey	Bergen, Essex, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Passaic, Somerset, Sussex, Union and Warren.
		New York	Albany, Bronx, Columbia, Delaware, Dutchess, Green, Kings, Nassau, New York, Orange, Putnam, Queens, Rensselaer, Richmond, Rockland, Schenectady, Suffolk, Sullivan, Ulster and Westchester.
3	Room 1200, New United States Customhouse, 2nd & Chestnut Streets, Philadelphia 6, Pa.	Delaware	Newcastle.
		New Jersey	Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Ocean, and Salem.
		Pennsylvania	Adams, Berks, Bucks, Carbon, Chester, Cumberland, Dauphin, Delaware, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Perry, Philadelphia, Schuylkill and York.
4	508 Old Town Bank Bldg. Gay Street & Falsway Baltimore 2, Maryland	Delaware	Kent and Sussex.
		District of Columbia	All.
		Maryland	All counties.
		Virginia	Arlington, Clark, Fairfax, Fauquier, Frederick, Loudoun, Page, Prince, William, Rappahannock, Shenandoah and Warren.
		West Virginia	Eastern part.
5	Room 402 New Post Office Building Norfolk 10, Virginia	North Carolina	All except district 6.
		Virginia	All except district 4.
6	411 Federal Annex Atlanta 3, Georgia	Alabama	All except district 8.
		Georgia	All counties.
		North Carolina	Ashe, Avery, Buncombe, Burke, Caldwell, Cherokee, Clay, Cleveland, Graham, Haywood, Henderson, Jackson, McDowell, Macon, Madison, Mitchell, Polk, Rutherford, Swain, Transylvania, Watauga and Yancey.
		South Carolina	All counties.
		Tennessee	do.
	Sub-Office P. O. Box 77 214-218 Post Office Bldg. Savannah, Georgia		

Radio District	Address of the Inspector in Charge	Territory Within District	
		States, etc.	Counties
7	P. O. Box 150 312 Federal Building Miami 1, Florida	Florida	All except district 8.
	Sub-Office 409-410 Post Office Bldg. Tampa 2, Florida		
8	400 Audubon Building New Orleans 16, La.	Alabama Arkansas Florida Louisiana Mississippi Texas	Baldwin and Mobile. All counties. Escambia. All counties. do. City of Texarkana only.
9	216 U. S. Appraisers Bldg., Houston, Texas	Texas	Arkansas, Brazoria, Brooks, Calhoun, Cameron, Chambers, Fort Hidalgo, Jackson, Jefferson, Jim Wells, Kenedy, Kleberg, Matagorda, Nueces, Refugio San Patricio, Victoria, Wharton and Willacy.
	Sub-Office 404 Post Office Bldg., Galveston, Texas		
10	P. O. Box 5238 500 U. S. Terminal Annex Dallas 2, Texas	New Mexico Oklahoma Texas	All counties. do. All except district 9 and the city of Texarkana.
11	539 U. S. Post Office & Courthouse Bldg., Temple and Spring Streets, Los Angeles 12, Calif.	Arizona California	All counties. Imperial, Inyo, Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara and Ventura.
	Sub-Office 307 U. S. Customhouse & Courthouse Building Union & "F" Streets San Diego 1, California	Nevada	Clarke.
12	328 Customhouse San Francisco 26, Calif.	California Nevada	All except district 11. All except Clarke.
13	805 Terminal Sales Bldg. Portland 5, Oregon	Idaho Oregon Washington	All except district 14. All counties. Wahkiakum, Cowlitz, Clark, Skamania and Klickitat.
14	808 Federal Office Bldg Seattle 4, Washington	Idaho	Benewah, Bonner, Boundary, Clearwater, Idaho, Kootenai, Latah, Lewis, Nez Perce, Shoshone.
		Montana Washington	All counties. All except district 13.
15	504 Customhouse Denver 2, Colado	Colorado Utah Wyoming	All counties. do. do.

Radio District	Address of the Inspector in Charge	Territory Within District	
		States, etc.	Counties
16	208 Uptown Post Office & Federal Courts Bldg. 5th & Washington Sts. St. Paul 2, Minnesota	Minnesota	All counties.
		Michigan	Alger, Baraga, Chippewa, Delta, Dickinson, Gogebie, Houghton, Iron, Keweenaw, Luce, Mackinac, Marquette, Menominee, Ontonagon, and Schoolcraft.
		North Dakota	All counties.
		South Dakota	do.
		Wisconsin	All except district 18 and Winnebago.
17	809 U. S. Court House Kansas City 6, Missouri	Iowa	All except district 18.
		Kansas	All counties.
		Missouri	do.
		Nebraska	do.
18	246 U. S. Court House Chicago 4, Illinois	Illinois	All counties.
		Indiana	do.
		Iowa	Allamakee, Buchanan, Cedar, Clayton, Clinton, Delaware, Des Moines, Dubuque, Fayette, Henry, Jackson, Johnson, Jones, Lee, Linn, Louisa, Muscatine, Scott, Washington and Winneshiek.
		Wisconsin	Columbia, Crawford, Dane, Dodge, Grant, Green, Iowa, Jefferson, Kenosha, Lafayette, Milwaukee, Ozaukee, Racine, Richland, Rock, Sauk, Walworth, Washington, Waukesha, Winnebago.
		Kentucky	Western part.
19	1029 New Federal Bldg. Detroit 26, Michigan	Kentucky	Eastern part.
		Michigan	All except district 16.
		Ohio	All counties.
		West Virginia	Western part.
	Sub-Office 541 Old Post Office Bldg. Cleveland 14, Ohio		
20	328 Federal Building Buffalo 3, New York	New York	All except district 2.
		Pennsylvania	All except district 3.
21	609 Stangenwald Building Honolulu 1, Territory of Hawaii	Territory of Hawaii	
		Guam	
		Midway	
		Wake	
		American Samoa	
		Outlying Pacific Posessions except Alaska	
22	P. O. Box 2987 322-323 Federal Bldg. San Juan 13, Puerto Rico	Puerto Rico	
		Virgin Islands	
23	P. O. Box 1421 7-8 Shattuck Bldg. Juneau, Alaska	Alaska	

CHAPTER TWO

Radio Parts and Symbols

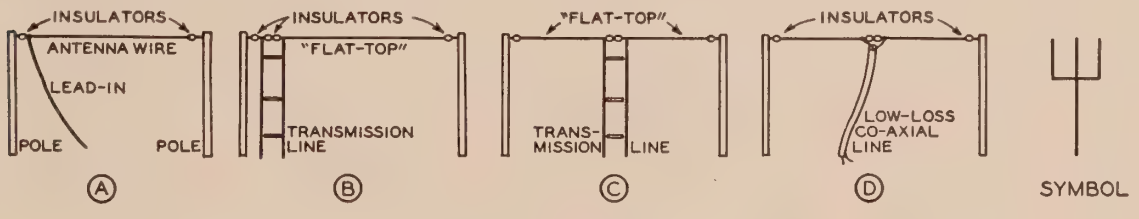
All radio instruments, such as transmitters, receivers, and test equipment, are composed of certain standard components, or "parts," which are assembled mechanically and connected together electrically. These parts, such as tubes, coils capacitors, etc., all are obtainable at regular radio parts stores. While it is possible for the amateur to manufacture his own parts, he will find it more convenient, and cheaper as well, to buy factory-made parts. Very few amateurs know how to build such parts as tubes or batteries, or have access to the equipment for making them.

An entire book could be devoted to radio parts and how they work. Not all of the components can be included in this chapter. However, we show the most important parts in Figures 1 to 38. These are the parts the newcomer will be most apt to use and should know about. In each case, we show the corresponding standard symbol used in radio wiring diagrams.

Antenna Figure 1 shows types of antenna commonly employed in amateur radio. Any one of those illustrated may be used both for transmitting and receiving.

In transmitting, the purpose of the antenna is to set up radio waves which then travel through space to distant receiving antennas. This is accomplished by feeding into the antenna electrical energy generated by the transmitter. In receiving, the antenna picks up electrical energy from passing radio waves and delivers it to the receiving set. If desired, the regular transmitting antenna may be switched over to the receiver for listening, thus making it do double duty.

Most amateur antennas consist of a single horizontal or slanting wire, cut to a specified length and hung between insulators attached to poles, chimneys, or other supports as high in the air as possible. A "down wire," or wires, known as a *transmission* line is connected between the horizontal antenna wire and the transmitter or receiver. In 1-A, a single wire (or *lead-in)* is connected to the antenna. In 1-B, the transmission line consists of two wires separated by insulators and connected to one end of the antenna. In 1-C, the



ANTENNAS

FIGURE 1

same type of transmission line is connected to the center of the antenna. In 1-D, the transmission line connected to the center of the antenna consists of a length of coaxial (concentric) cable (See also Figure 3-B).

Batteries The simplest source of direct current is the battery. Batteries produce electricity as a result of chemical action. Batteries consist of several *cells* in which this chemical action is generated. Figure 2-A shows two types of *dry cells*. Radio "B" batteries consist of 15 or more such cells (of small size) wired together electrically. Figure 2-B shows a *storage battery*. The storage battery has the advantage that it may be "charged," or restored, by connecting it for a time to some other source of electricity after its own supply has been depleted. Dry cells, on the other hand, must be discarded when they no longer deliver required current and voltage.

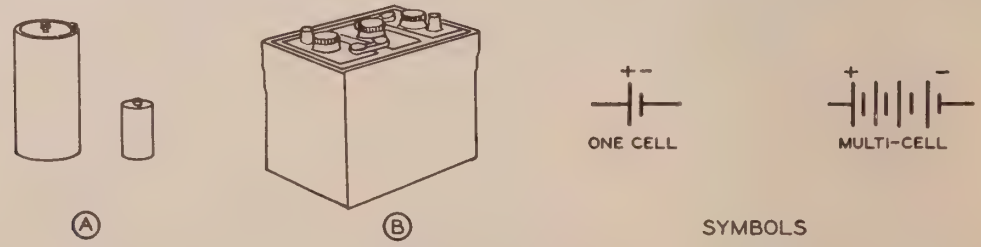
Cables For connecting parts together in radio instruments, the amateur usually employs single lengths of wire, often insulated. However, certain special connections require the use of lines or cables of special design. The two types of cable most frequently employed are shown in Figure 3. At 3-A is shown a length of *twisted pair*. This consists of two tightly twisted wires, each covered with a jacket of high-grade ("low-loss") insulation. Figure 3-B shows the construction of the second type which is known as flexible *coaxial* or *concentric* cable. In the latter type, one conductor is a straight wire, while the other is a metallic tube or sheath completely surrounding the wire. The two are insulated from each other by means of the intervening air space or a flexible low-loss insulating material.

Both twisted pair and coaxial lines are in wide use by amateurs for conveying radio currents from one point to another. An example is the antenna transmission line in Figure 1-D.

Capacitors The capacitor, also called a *condenser*, is one of the commonest radio components. This device stores electricity and delivers it when needed. The time between the storing and delivery often is much less than a millionth of a second. Because the capacitor blocks the passage of direct currents, while admitting alternating currents with comparative ease, it finds many uses in radio circuits.

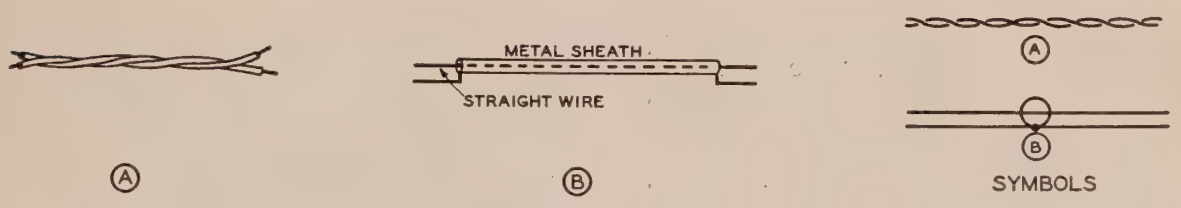
The capacitor is a simple device. It consists basically of two pieces of conducting material separated either by an air space or a sheet of insulating material—the *dielectric*. The pieces of conducting material usually take the form of plates, and several pairs of such plates may be combined in a single capacitor to increase its electrical size.

The amount of electricity which may be stored by a capacitor depends up-



BATTERIES

FIGURE 2



CABLES

FIGURE 3

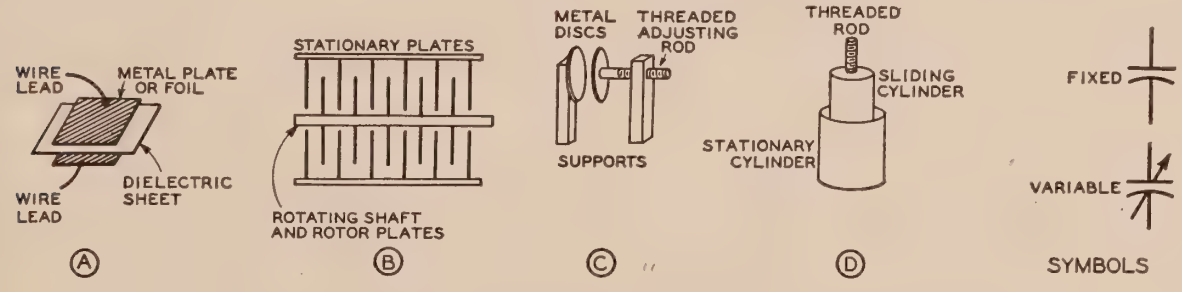
on the area of the metal plates, the distance by which they are separated, and the dielectric material (air or other insulator) placed between them. The property whereby the capacitor operates is termed *capacitance*. A capacitor with large plates separated a certain distance will have a larger capacitance than one with smaller plates separated the same distance. Capacitance is rated in *microfarads* (uf) and *micro-microfarads* (uuf).

If a capacitor is so constructed, as in Figure 4-A, that the area of its plates and their separation cannot be changed, its capacitance always will be one definite value. Such a unit accordingly is called a *fixed* capacitor. If, on the other hand, a capacitor is so constructed that one of its dimensions can be changed at will, its capacitance can be altered, and the unit becomes a *variable* capacitor. Figures 4-B, 4-C, and 4-D show construction of common types of variable capacitors.

The device shown in Figure 4-B consists of several semi-circular metal plates fastened to a metal shaft turned by means of a graduated dial. These plates rotate between, but not touching, a series of stationary metal plates which form the rest of the capacitor. The electrical effect of the combination is that of several two-plate capacitors connected in parallel. The distance between the stationary and rotating plates always is the same. But as the shaft is rotated, more or less of the area of the rotary plates faces the adjacent stationary plates, giving the effect of changing the plate area. The result is that the capacitance of the unit is varied by rotating the rotary plates.

In Figure 4-C, the two round, metal plates have identical areas, but the distance between them changes as the threaded rod to which one plate is attached is rotated. This varies the capacitance.

In Figure 4-D, two metal cylinders are separated by an air space and so mounted that one slides in and out of the other as the threaded rod is rotated. Thus, the separation between the walls of the two cans remains constant, but the "effective" area is changed—resulting in variation of the capacitance.



CAPACITORS

FIGURE 4

Figure 5 shows a group of fixed capacitors used in radio. The first and third units in the front row have the general internal construction shown in Figure 4-A, while the second, fourth, and fifth capacitors consist of long 2-plate units of similar construction which have been rolled up to conserve space. The first and third units are molded in bakelite, the second enclosed in a cardboard cylinder, the fourth in a rectangular metal can, and the fifth unit in a cylindrical can.

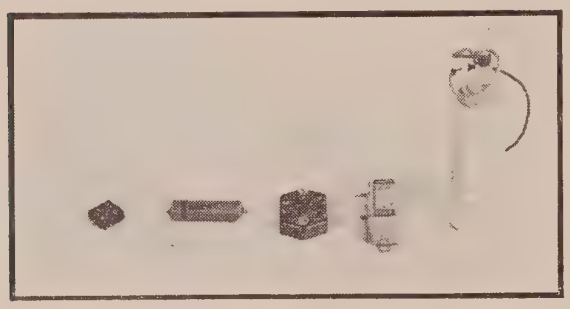


FIGURE 5

Group of typical fixed capacitors. Left to right are postage-stamp mica; paper tubular; small transmitting type mica; metal-cased ("bath tub") paper; and metal can-enclosed electrolytic.

Figure 6 shows a group of variable capacitors. The first consists of three "ganged" units of the type illustrated by Figure 4-B. The rotors are electrically and mechanically connected together and "tuned" by means of one shaft.

The second variable capacitor consists of two metal plates separated by a thin leaf of mica. A screw allows one of the plates to be moved, varying the separation between the two. The third and fourth units in the photograph have the construction illustrated by Figure 4-B.

Chokes A choke is a type of inductor or coil. It usually consists of turns of insulated

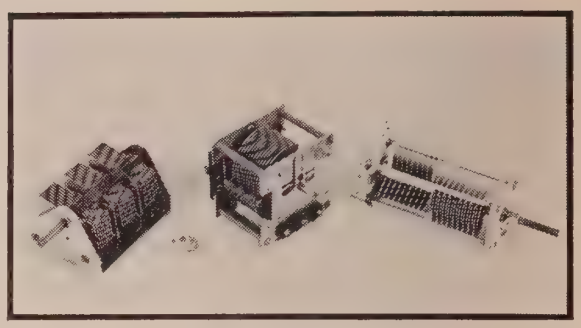


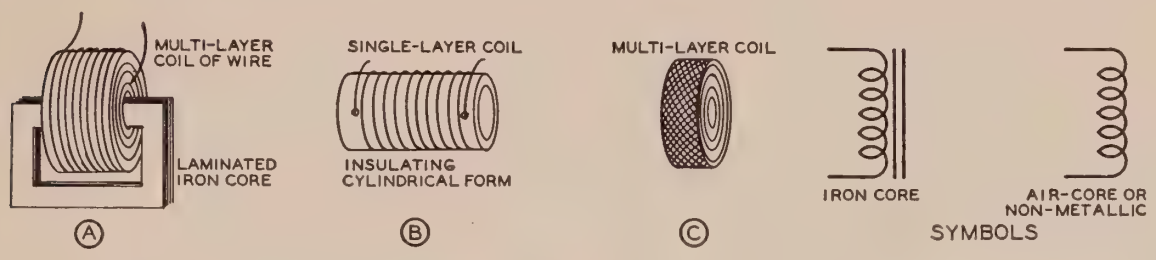
FIGURE 6

Group of typical variable capacitors. Left to right are 3-gang variable; small compression-type 2-plate mica insulated; single-gang; and 2-gang medium power transmitting type.

wire wound side by side. The turns of wire may be wound in a single layer or a number of layers on a cylindrical or rectangular form of insulating material, such as plastic or treated cardboard, as shown in Figure 7-B, or the coil may be wound by criss-crossing *(lattice winding)* the turns in each layer, as shown in 7-C. When a choke consists of only a few turns of stiff wire, no supporting form is needed and the coil is said to be *air wound.*

Chokes used at low frequencies are provided with laminated iron cores, as shown in Figure 7-A. Those intended for high frequencies either have no cores at all, and are said to be of the air-core type, or they have special cores of powdered iron.

The choke operates by electromagnetic action. In a circuit it offers appreciable opposition (depending upon its own dimensions) to the flow of an alternating current while allowing comparatively free passage to a direct current. The choke is said to have *reactance* for alternating currents. A choke of a given size (number of turns, etc.) will offer more reactance to alternating currents of certain frequencies than to currents of other frequencies. Because of this action chokes are invaluable in any part of a circuit where a direct



CHOKES

FIGURE 7

current must be passed but an alternating current held back.

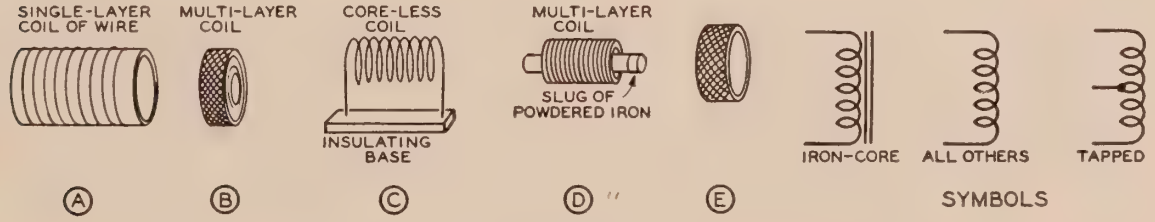
The reactance of a choke to alternating currents is due to the magnetic field built up about the coil by the current flowing through it. This field opposes any fluctuations or changes in the current. An alternating current is constantly changing and consequently may be impeded, or even blocked, by the choke. A direct current, on the other hand, flows in one direction without fluctuations and encounters no limitation.

Figure 8 shows a group of low- and high-frequency chokes. The first unit is an iron-core type designed for audio frequencies. The next two are radio-frequency chokes wound according to the scheme illustrated by Figure 7-C.

FIGURE 8

Choke coils. The left hand unit is a small iron-core type used in receiver power supplies. The center unit is a "pi-wound" radio-frequency choke used in both receivers and transmitters. The righthand r. f. choke has high inductance for its size and is intended for lower frequencies than the center r. f. choke.

Coils Like chokes, radio coils are also inductors and consist of turns of wire either air wound or wound on forms or cores. In general, high-frequency coils are air wound or are supported by cylindrical forms. Most high-frequency coils are wound in a single layer. High-frequency coils do not have solid iron cores like the chokes shown in Figure 7-A and the first unit in Figure 8. However, they often are provided with powdered iron cores, as in Figure 9-D. Some high-frequency coils are of the multi-layer type; that is, they are wound in several layers on a spool or bobbin of insulating material (See Figure 9-B) or lattice wound or air wound, as in Figure 9-E.



COILS

FIGURE 9

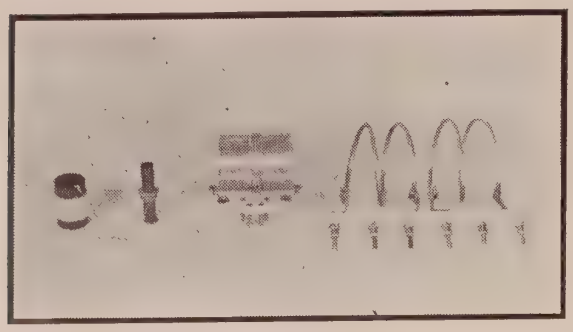


FIGURE 10

Typical r. f. coils. The two left-hand coils are wound on cylindrical insulating forms. The first is wound in one layer; the second in three lattice-wound sections called "pi's." The two right-hand coils are for transmitters and are air wound.

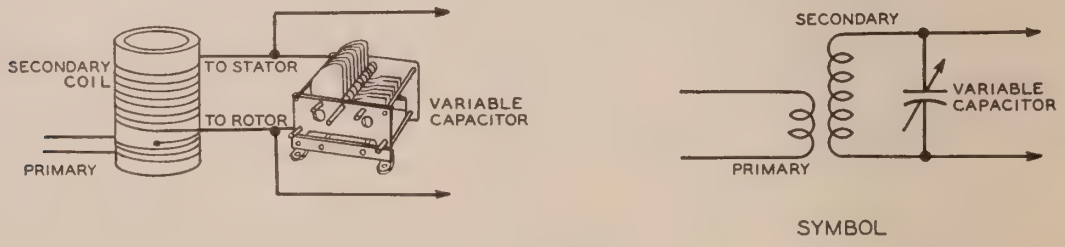
Figure 10 shows a group of typical radio coils. The first is a single-layer coil wound on a bakelite form, the second a lattice wound unit on a bakelite tube, and the last two are air-wound coils provided with plug bases. The first two coils are for use in receivers; the last two for transmitters.

Coils, like the chokes descibed in the preceding section, operate by means of electromagnetism. They offer reactance to the flow of an alternating current. The electrical size of any coil, choke or otherwise, is reckoned in terms of *inductance,* a property which depends upon the diameter and length of the coil and the number of turns of wire it contains. Inductance is measured in *henries (hy) millihenries (mh.*—thousandths of a henry), and microhenries (*uh*—millionths of a henry). A coil having a given length and diameter and wound with fine wire will have more turns and therefore more inductance than a coil of the same length and diameter wound with heavier wire which would afford less turns. Likewise, a coil having a given length and number of turns will have a larger inductance for a large diameter than for a small diameter.

A *tap* connection made to some intermediate turn along the length of the coil will permit selection of a fraction of the total inductance of the coil.

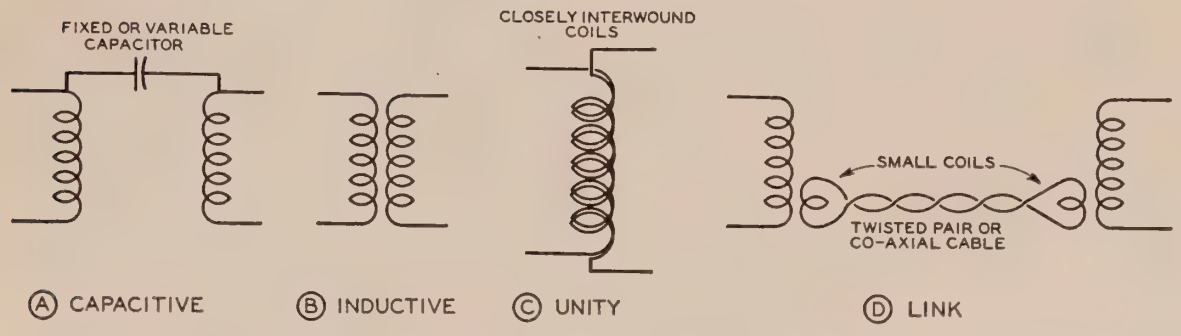
Coupler The coupler is a tuning unit. It enables the operator to select signals of one frequency, while automatically rejecting those on all other frequencies. Basically, a tuned coupler consists of two closely situated coils and a variable capacitor, as shown in Figure 11. The small primary coil usually is wound on the same form and close to the secondary coil. The variable capacitor is connected in parallel with the secondary coil.

Currents, such as those flowing from a receiving antenna, are caused to flow through the primary coil. The magnetic field which then is set up about the primary induces a current in the secondary coil which causes a voltage to be developed across the coil. This voltage then may be applied to a tube or other component. The frequency to which the coupler is tuned is governed by the inductance of the secondary coil



COUPLER

FIGURE 11



COUPLING SYSTEMS

FIGURE 12

and the capacitance of the variable capacitor. By varying the capacitor, the coupler may be tuned to signal frequencies over a relatively wide range.

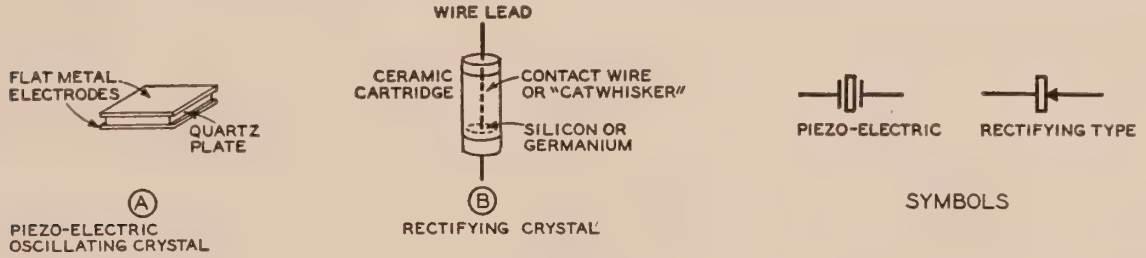
Coupling Systems The systems shown in Figure 12 are employed to transmit radio energy from one point to another within a radio instrument or from one instrument to another. At 12-A, a simple fixed capacitor is employed to conduct high-frequency currents from the first coil to the second.

At 12-B, the magnetic field surrounding the first coil, as a result of currents flowing through the latter, sets up a voltage across the second coil by electrical induction. In inductive coupling of this sort, the pickup coil must be placed close enough to the "generating" coil to secure a useful transfer of energy across the air gap.

Another form of inductive coupling is shown at 12-C. Here, in order to transfer the maximum amount of energy, the two coils are closely interwound on the same form.

A special form of inductive coupling is shown at 12-D. Here, a small "pick-up coil" is coupled to the generating coil and a similar small "delivery coil" to the remote coil. The two small coils are connected together by means of a length of twisted pair or coaxial cables. (See Figures 3-A and 3-B for constructional details of these cables.) Energy is set up inductively in the first small coil and the resulting currents are carried by the cable to the second small coil. The magnetic field about the latter then induces a voltage in the second large coil. Link coupling, as this arrangement is called, is widely used in amateur transmitters.

Crystals Two forms of crystals are available for radio use. Both are shown in Figure 13. The first (Figure 13-A) is the piezoelectric crystal used to set, or control the frequency of a transmitter. This crystal



CRYSTALS

FIGURE 13

consists of a thin slab or plate of quartz provided with two metal electrodes.

When a voltage is impressed upon the faces of the quartz plate connected in a suitable tube circuit, the slab vibrates at a certain number of kilocycles per second determined by its thickness. This vibration then is employed to control the transmitter which sends out signals on the same frequency.

The second type of crystal is shown in Figure 13-B. This device performs an entirely different function. In order to be useful in headphones or loudspeaker, radio signals, which are high-frequency alternating currents, must be rectified or converted into a direct current with a low frequency alternating current component which carries the intelligence or modulation. When such alternating currents are applied to the *rectifying crystal,* they are so converted.

The rectifying crystal consists of a slug or block of suitable material (in this case, Germanium) in contact with which is placed a thin, springy wire called the *catwhisker.* Electric currents flow much more readily through this combination in one direction than in the opposite. The result is that an alternating current is rectified, which is to say one set of alternations is passed while the other set is blocked. Current delivered by the crystal according flows almost completely in one direction and so resembles direct current.

Figure 14 shows a group of radio

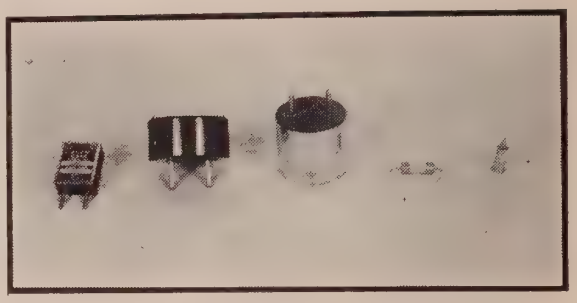


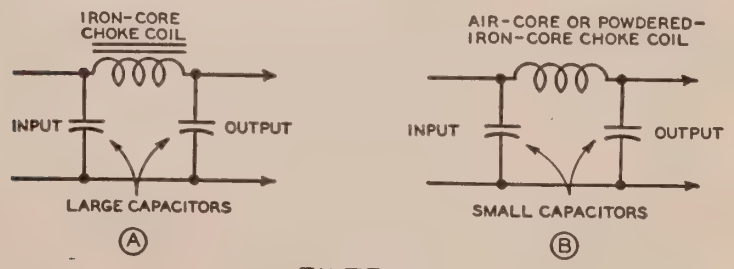
FIGURE 14

Crystals. The first three are quartz plates for transmitter control; the last two act as rectifiers in receivers and test instruments. The two types are dissimilar as to characteristics and application but carry the same name.

crystals. The first three are quartz crystals for transmitter control. Each is mounted in a protecting holder provided with plugs for quick connection into the transmitter circuit. The last two are rectifying crystals constructed internally like the unit illustrated in Figure 13-B.

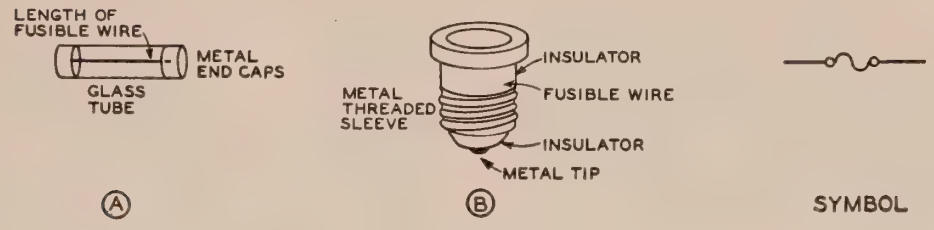
Filters When alternating current is converted into direct current by means of a rectifier, the direct current obtained is not as smooth flowing as that delivered by a battery. A filter, consisting of large capacitors and a high-inductance iron-core choke coil (See Figure 15-A) is employed to smooth out this current.

Filters are very useful in radio circuits in another respect. They may be employed to pass a desired frequency or band of frequencies, while rejecting other frequencies—or to reject a certain frequency or band while passing all



FILTERS

FIGURE 15



FUSES
FIGURE 16

others. The frequencies at which filters operate are determined by the inductance of the choke coils and capacitance of the capacitors used in the circuits. Low-frequency filters (See Figure 15-A) employ iron-core chokes and large capacitances, while high-frequency filters (Figure 15-B) employ air-core or powdered-iron core chokes and small capacitances.

Fuses Power-line fuses for protecting all forms of radio apparatus operated from the commercial power mains are familiar to all electrical workers. The two types of fuses in general amateur radio use are shown in Figures 16 and 17. The small glass-tube type (Figure 16-A) is widely used in receivers and low-powered transmitters, since it is compact and requires only small mounting space. This type of fuse has found some application too in the protection of electrical meters. The plug type (Figure 16-B) is very familiar, being the type employed in house wiring.

The fuse operates on the simple principle that an abnormal increase in current (amperes) will cause the fusible wire to melt, thereby opening (disconnecting) the circuit.

Ground An earth or *ground* connection usually is required by receivers, transmitters, and some antennas. The best grounds are secured by means of a tight connection to a long pipe driven deep into moist soil (Figure 18), or by tight connection to a cold water pipe. Gas pipe grounds or connections to heating radiators are not recommended.

Jacks and Plugs A jack and plug permit portions of a circuit to be connected or disconnected quickly and simply. Figure 19 shows two types of jacks and plugs used in amateur radio equipment.

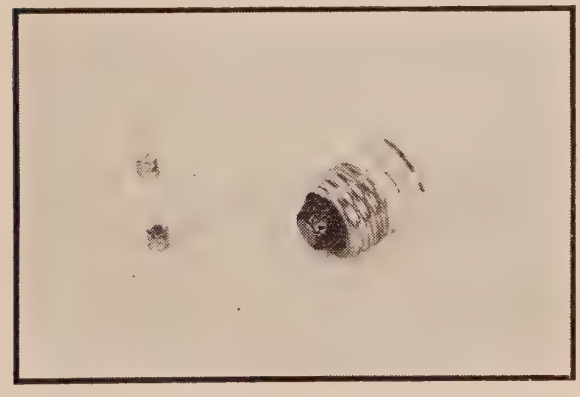
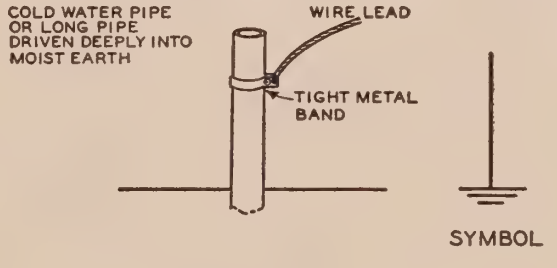


FIGURE 17
Fuses. A glass-enclosed tubular type is shown on the left; a plug-in type on the right. The smaller type is useful for the protection of meters.

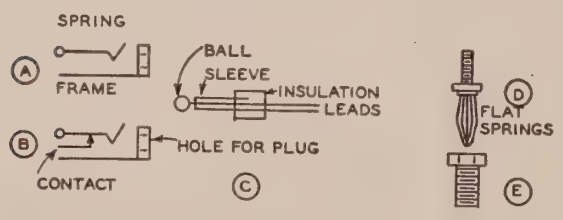


GROUND
FIGURE 18

Figures 19-A and 19-B show two types of spring jacks, while 19-C is the plug used with these jacks. The two leads from the external circuit are connected respectively to the ball and metallic sleeve of the plug. Ball and sleeve are insulated from each other. When the plug is inserted into the jack, the ball makes contact with the jack spring and the sleeve contacts the jack frame. Figure 19-B is a special form of spring jack in which the plug's ball, pushing the main jack spring upward, breaks a second circuit formed through the upper spring and auxiliary contact. Other types of spring jacks make it possible to open or close several circuits simply by inserting the plug.

Figure 19-D shows a widely used form of plug consisting of a screw with several longitudinal flat springs. Because of its shape, this type is known as a *banana plug*. The jack matching this plug is shown in Figure 19-E and consists of a plain, wide, flathead screw through which a central, longitudinal hole has been drilled. When the banana plug is inserted "home" in the hole of the jack, the plug springs make a tight rubbing contact with the inside wall of the jack.

Banana plugs may be seen on the bases of the two right-hand coils in Figure 10. A *telephone* plug of the type shown in Figure 19-C may be seen on the end of the meter leads in Figure 25.



JACKS AND PLUGS

FIGURE 19

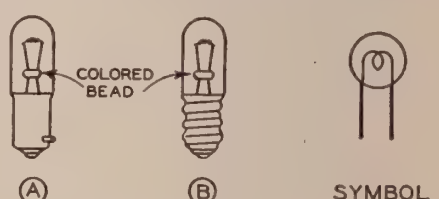
Telegraph Key The key, shown in Figure 20, is employed, as will be described later, in transmitting code signals. The telegraph key is a type of switch. The circuit to be controlled is connected by leads to the bar and lower contact of the key. When the key is depressed, the two contacts meet and the circuit is closed. When finger pressure is released, the spring returns the bar to its normal upward position, forcing the contacts apart and opening the circuit.

TELEGRAPH KEY

FIGURE 20

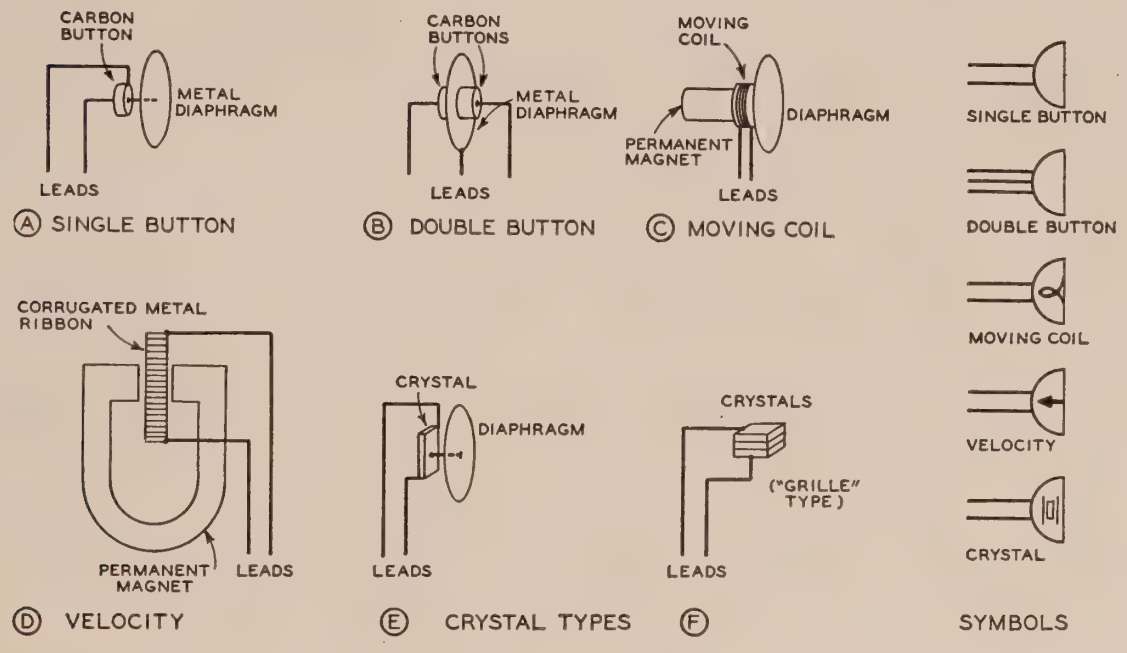
Pilot Light Radio dials and meters are illuminated by small incandescent lamps usually operated at 2½ or 6.3 volts. Some battery-operated portable instruments employ 2-volt lamps, although it is customary to eliminate pilot lights in this type of equipment in order to reduce battery drain.

These miniature lamps are obtainable in two types; with "twist-in" or *bayonet base* (Figure 21-A) and with "screw-in" or *candelabra* base (Figure 12-B). Special sockets are manufactured for pilot lamps.



PILOT LIGHT

FIGURE 21



MICROPHONES
FIGURE 22

Microphones The heart of a radiotelephone transmitter is the *microphone.* The six types of microphones employed by radio amateurs are shown in Figue 22. Any microphone essentially is a device for converting sound waves, set up by music or the voice, into electrical pulsations.

Figure 22-A shows the most economical type of microphone. Here a diaphragm, which is set into vibration by sound waves, transfers its movement to a small container of carbon granules—the *carbon button.* The vibrations alternately compress and release the granules, lowering and raising the resistance of the button. Direct current from a battery is passed through the button and is converted into pulsations by the voice-controlled resistance of the button. This type of microphone not only is inexpensive itself, but requires less amplification than other types.

In the double-button type of carbon microphone (See Figure 22-B), a carbon button is placed on each side of the diaphragm in order to utilize the full vibration and to reduce the harmonic distortion inherent in the single-button type.

In Figure 22-C, a dynamic microphone is shown. This type actually generates an alternating current. A small coil is attached to the vibrating diaphragm or cone and this coil moves back and forth in the field of a permanent magnet. This motion in the magnetic field causes an alternating current to be set up in the coil which produces voltage across the coil. The alternations of the induced voltage follow the voice vibrations and may be applied through a transformer to the speech amplifier tube in the transmitter.

The *velocity microphone* (Figure 22-D) also operates by means of electrical induction. But in this case, a thin corrugated metal ribbon, vibrated by sound waves, is suspended in the field of a permanent magnet.

The other voltage-generating micro-

phones are shown in Figures 22-E and 22-F. These employ piezoelectric crystals—usually of Rochelle salt. In the first type (Figure 22-E), a metal diaphragm conveys sound vibrations to the crystal held between metal electrodes. Alternate vibrations compress and stretch the crystal, causing it to set up a voltage which fluctuates in sympathy with the impressed sound waves. This voltage then is applied to the speech amplifier. In the second type of crystal microphone (Figure 22-F), the diaphragm is omitted and sound vibrations are applied directly to several crystals assembled into a so-called *sound cell.*

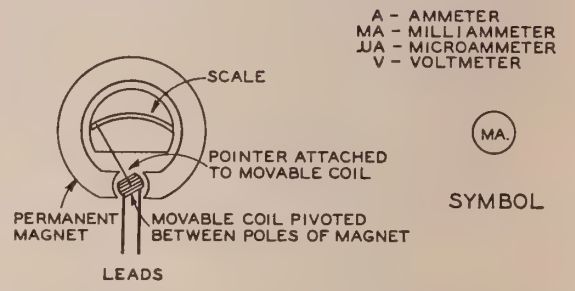
Figure 23 shows the external appearance of a diaphragm type crystal microphone which is very popular among amateur radiotelephone operators.

Meters Electrical meters or indicating instruments are employed in amateur radio principally for measuring voltage and current. In amateur transmitters, the most widely used instrument is the d-c milliammeter, which shows the important tube operating current value and acts as a tuning indicator as well.

The principal of the moving-coil d-c instrument is illustrated by Figure 24.

FIGURE 23

Crystal microphone of the diaghram type, which is the type most widely used by amateurs.



METER

FIGURE 24

A coil of fine wire is mounted on jewelled pivots between the poles of a strong permanent magnet, and an indicating pointer is attached to the coil frame. When a direct current is passed though the coil, the latter is turned (as a result of action between the magnetic field set up around the coil by the current and the field of the permanent magnet) on its axis against the pressure of a pair of light coil springs. The length of the arc through which the coil turns is proportional to the current flowing through the coil. That is, the stronger the current the more the coil will turn away from its position of rest. A scale accordingly may be mounted under the pointer and marked off in current units, such as amperes or milliamperes. When the current is removed, the pressure of the coil springs act to return the coil and pointer to the extreme left-hand *zero position.*

Most currents measured in amateur radio instruments are relatively small, being in *milliamperes* (thousands of an ampere). The *milliammeter* therefore is the most widely used instrument in this equipment.

Figure 25 shows a group of meters, revealing the sizes and shapes of cases in which these instruments are supplied.

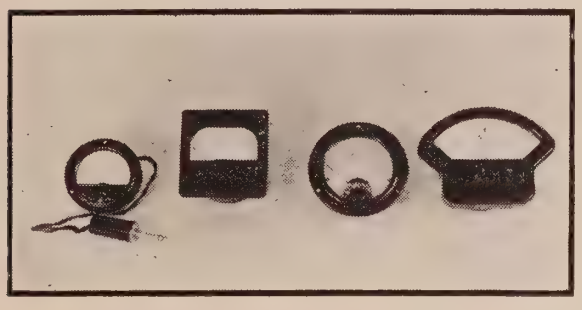


FIGURE 25

Meters employed in amateur work. The first, second, and fourth are d.c. milliameters. The third is an a.c. milliameter. The fourth has a "center zero" and therefore is better adapted to certain indicating functions where a polarized indicator is desirable or necessary.

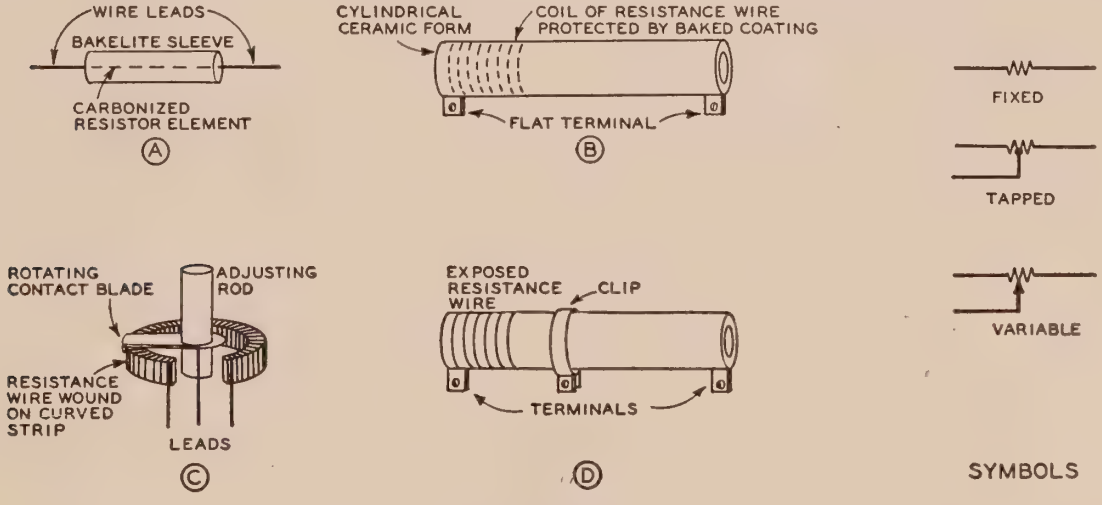
Resistors Resistance units or *resistors* rank with capacitors and coils or inductors in widespread appearance in radio instruments.

Operation of the resistor is based upon the fact that certain materials (notably carbon and certain metals like Nichrome, German silver, etc.) offer enough opposition or *resistance* to the flow of electricity that they will considerably impede the flow of a current. Whenever it is desired to reduce current flow, a resistance unit conveniently may be inserted into a circuit.

Electrical resistance is measured in *ohms* and is governed by the type of resistance material in use, its length, and cross-sectional area.

A fixed resistor has a definite, unadjustable length of resistance material either mounted straightwise between two leads or terminals (See Figure 26-A) or wound around a fireproof, insulating form (Figure 26-B). Its value in ohms therefore cannot be altered.

In a variable resistor, some means is provided for using various amounts of the resistance wire in order to obtain desired resistance values which are fractions of the total available resistance of the unit. One such method is shown in Figure 26-C. Here, bare resistance wire is wound in a continuous coil around a curved strip of insulating material. In contact with the wire is a flat metallic blade which may be set at will to contact various points around the curved coil, cutting more or less of the resistance wire in for use. Radio volume controls and rheostats



RESISTORS

FIGURE 26

have this construction. Another method is shown in Figure 26-D. Here, a circular metallic band or "clip" is mounted around the "resistor stick" in such a way that it may be moved along the coil of resistance wire and so contact more or less of the wire length. A screw permits tightening and locking of the band in place, once the desired resistance value has been located. A resistance unit also may be provided with taps when definite intermediate values are preferred to continuous variation of resistance.

Figure 27 shows a group of resistors. The first unit is a small bakelite-insulated carbon resistor of the type shown in Figure 26-A. The next two are of the types illustrated by Figures 26-B and 26-D respectively. The last unit in the photograph is a volume control having internal construction similar to that illustrated by Figure 26-C.

FIGURE 27

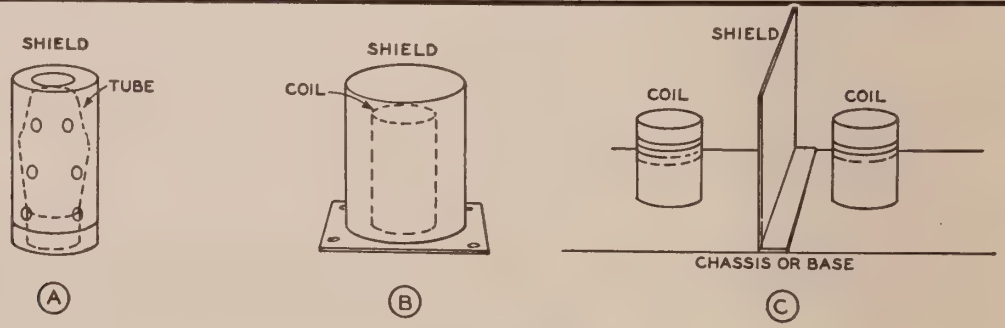
Resistors. The first three are fixed resistors. The fourth is a variable resistor (rheostat-potentiometer) of the receiver volume control type.

Shields Metal cans and partitions are employed in radio instruments to reduce or eliminate unwanted coupling between various parts. Shielding is made possible by the ability of a suitable metal barrier to hold back magnetic or static lines of force or to reduce their intensity.

Can-type shields of copper or aluminum (See Figures 28-A and 28-B are used with coils and tubes, while *baffles* (upright metal partitions) are commonly employed to separate groups of parts. Often an entire group of components will, after wiring together, be enclosed entirely in a metal box to obtain complete *stage shielding*.

Tube Sockets The bases of radio tubes are provided with "pins" (connected with electrodes inside the tube) which fit into tight-gripping contact springs when the tubes are inserted into the radio equipment. These springs are arranged around a circle on an insulating disc or base. Springs and base make up a tube socket. Such an arrangement of socket and tube pins form a jack and plug system which makes an easy matter of replacing tubes in instruments. Tube sockets are supplied with insulating wafers of bakelite, ceramics, or low-loss plastics.

Figure 29 shows the bottom views of common tube sockets. Many tube types employ identical bases, and the



SHIELDS

FIGURE 28

BOTTOM VIEWS

TUBE SOCKETS

FIGURE 29

electrodes to which certain base pins (and therefore, socket terminals) are connected must be found out by consulting the tube manufacturer's tables or the tube connection charts in the *Radio Handbook.*

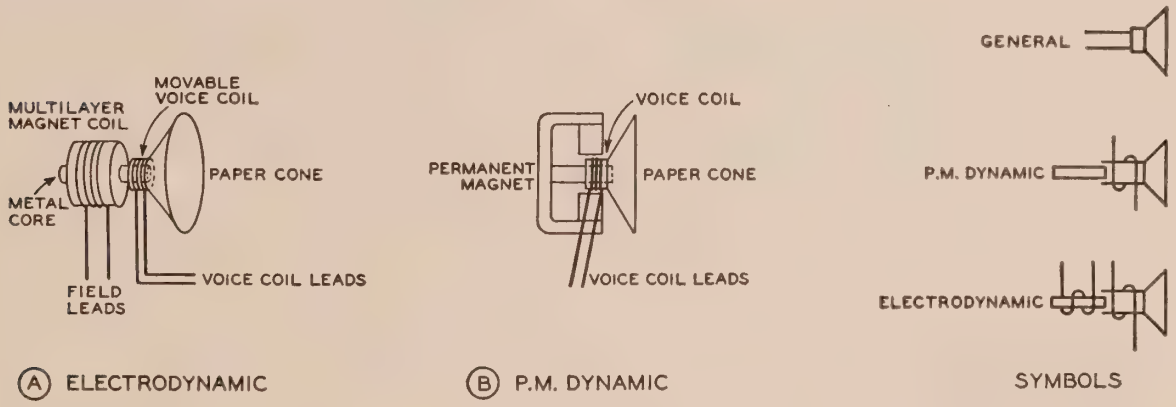
Figure 30 shows a group of tube sockets. The first and fourth are ceramic types, the second and third have bakelite wafers, and the last is a large ceramic-insulated type designed for a modern 5-pin transmitting tube.

FIGURE 30

Tube sockets. Left to right: ceramic wafer type; bakelite type; bakelite with metal mounting rim; ceramic with metal mounting rim; large ceramic transmitter type.

Speakers Two types of dynamic loudspeakers are in general radio use at the time of this writing. Their main constructional details are shown in Figure 31.

The operating principles of both types is the same. Alternating currents from the output amplifier of the radio receiver pass through a coil of fine wire *(voice coil)* attached to a stiff paper cone and situated within the field of a strong magnet. In Figure 31-A, an electromagnet is shown, while in Figure 31-B a speaker employing a permanent magnet is shown. The current in the voice coil causes a corresponding alternating magnetic field to be built up around the coil; and as this field changes its polarity alternately from north to south, it acts first with and



(A) ELECTRODYNAMIC (B) P.M. DYNAMIC SYMBOLS

LOUDSPEAKERS

FIGURE 31

then against the field of the magnet. The voice coil accordingly vibrates back and forth, and these vibrations are conveyed to the diaphragm (cone) which converts them into sound waves.

Switches The switches employed in radio are simple in principle and in no wise are different from those encountered elsewhere in the electrical field, except that they may be smaller than some others. Their principle of operation simply is to complete an external circuit by making contact between two portions of the switch. This simple principle is the basis of many ingenious switching mechanisms.

Figure 32-A shows the simple *knife* switch which closes an external circuit when the switch blade is thrust between the jaws of a pinch contact. Figure 32-B shows a single-deck rotary switch in which a rotatable metal blade makes contact successively with various metallic buttons (switch points) or clips arranged around a circle. Rotary switches often are composed of several decks all of which are adjusted simultaneously by rotating the one shaft.

Figure 33 shows a group of radio switches. The first is a knife switch with two poles (blades) and four sets of contacts, the second is a single-deck rotary switch, the third is a small "toggle" switch, and the fourth a rotary switch having several decks.

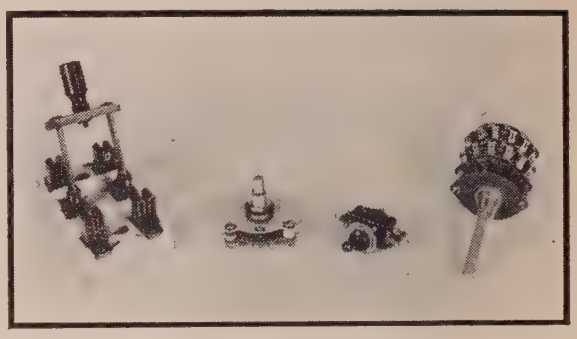
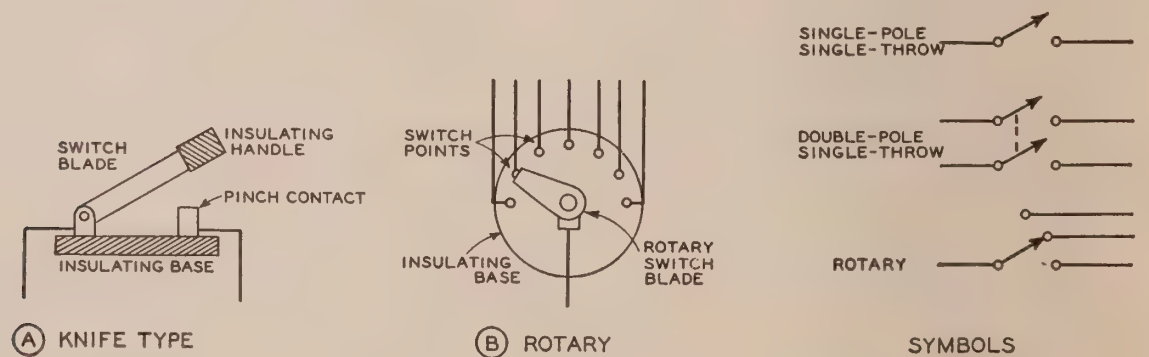


FIGURE 33

Switches. Left to right: double-pole, double throw knife type; single-gang rotary type; double-pole, double-throw toggle type; 3-gang rotary type.

Transformers Transformers are employed whenever it is desired to increase or decrease an a. c. voltage in the most efficient manner. Thus, there are *step-down* as well as *step-up transformers*. A transformer makes it possible to obtain 6 volts for tube heating purposes from the 115-volt house mains. Going in the opposite direction, a transformer likewise makes it possible to obtain from the 115-volt line the 1000 volts required to operate some transmitting tubes.

Transformers may be employed at



SWITCHES

FIGURE 32

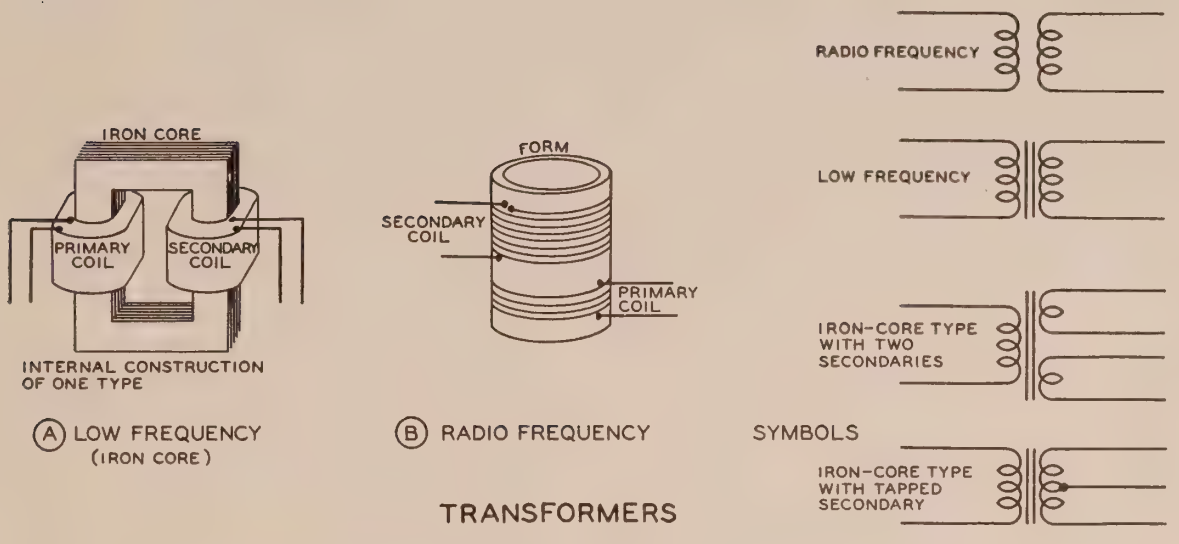


FIGURE 34

high (radio) frequencies as well as at low (audio and power-line) frequencies. Low-frequency types are provided with cores of laminated iron (See Figure 34-A), while high-frequency types are of air-core construction (See Figure 34-B) or have powdered-iron cores.

There are many variations in transformer construction other than the two illustrated by Figure 34, but all operate on the same principle. For example, in some types the coils are mounted on separate legs of the core, as shown in Figure 34-A, while in other types one coil is wound on top of the other.

Fundamentally, a transformer consists of two coils of wire mounted, with or without a supporting iron core, close enough together to provide magnetic coupling between the two. When an alternating current flows through one of the coils (primary coil), there is set up a magnetic field which passes through the other coil (secondary coil) and induces a voltage across the latter. This induced voltage is a function of the degree of coupling between the two coils and is also a function of the primary coil voltage and of the ratio between the number of turns in the two coils. As an example (and assuming a high coefficient of coupling as in a power transformer); if the secondary has half as many turns as the primary coil, the secondary voltage will be one-half the primary voltage. Conversely; if the secondary has five times as many turns as the primary coil, the secondary voltage will be 5 times the primary voltage. A secondary coil may be tapped, as shown in the lower symbol in Figure 34, in order to obtain a fraction of the available secondary voltage. Radio

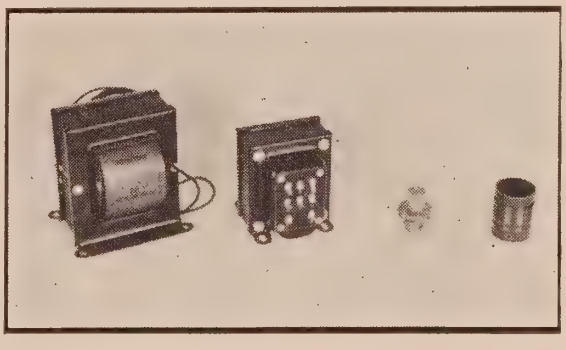


FIGURE 35

Transformers. Left to right: power type for heating a transmitting tube filament; audio type for transmitter modulation; low-frequency r.f. type; high-frequency r.f. type. While the latter two actually are transformers, r.f. transformers of this type often are referred to simply as "coils."

transformer secondaries often are center-tapped (that is, tapped at one-half the secondary turns). A single radio transformer often has a number of separate secondary coils for supplying various voltages.

Figure 35 shows a group of transformers. The two large iron-cored units are for power-line and audio-frequency operation respectively in radio transmitters. The two small air-cored units are for radio-frequency use in receivers.

Tubes For a complete understanding of radio tube operation, the newcomer is referred to the chapter entitled "Vacuum Tube Principles" in the *Radio Handbook*. Tube operation is explained also in the study guide (Chapter 10) of this book you are now reading. Space does not permit a complete chapter on tubes in this book for the newcomer; however, basic tube types of interest to all newcomers are illustrated by Figures 36, 37, and 38.

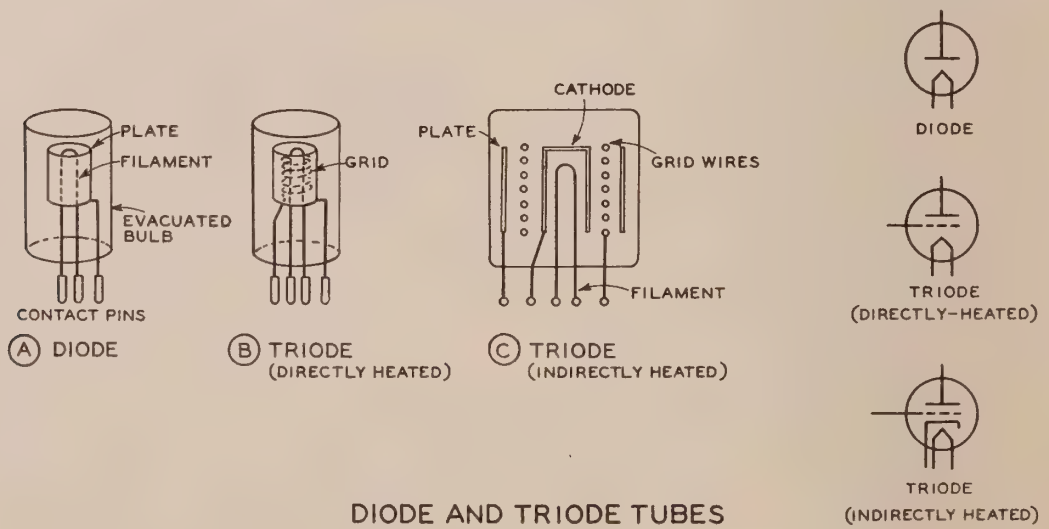
The simplest type is the *diode* or 2-element tube (Figure 36-A). The electrodes in this tube are a cathode (which may be either an incandescent filament or an indirectly heated cathode sleeve) and a metallic plate (often cylindrical, as shown in the drawing) mounted within an evacuated tube. Cathode and plate are not in contact with each other.

The *triode* or 3-element tube (Figure 36-B) contains, in addition to cathode and plate, also a *grid* coil or mesh mounted between cathode and plate.

Tetrodes (Figure 38-C) contain one additional grid—the *screen* — mounted between the first, or *control* grid, and plate. *Pentodes* (Figure 38-F) have still another grid—the *suppressor*—between screen and plate. *Beam tetrodes* (Figure 38-D) have a *beam deflector* electrode between screen and plate. *Pentagrid* tubes (Figure 38-G) have five grids.

In a number of tubes, several separate types are mounted within a single bulb. Such combinations are represented by the dual diode (Figure 38-A), dual triode (Figure 38-B), dual tetrode (Figure 38-E), diode-triode (Figure 38-H), and diode-pentode (Figure 38-I).

In the tubes shown in Figures 36-A and 36-B, electrons are emitted by the hot filament. Such tubes are said to be *directly heated*. A second scheme for obtaining electrons is illustrated by Figure 36-C and in all of the symbols in



DIODE AND TRIODE TUBES

FIGURE 36

Figure 38. Here, the filament is mounted inside an efficient electron emitting cylinder known as the *cathode*. The cathode is heated by radiation from the filament and is electrically insulated from the latter. Tubes using this scheme are said to be *indirectly heated*.

In some tubes, all internal electrodes are connected to pins protruding from the tube base. In other types, one or more connections may be brought out through the top or side of the tube bulb or *envelope*. The first type is called *single-ended*, while the second is described as *double-ended*.

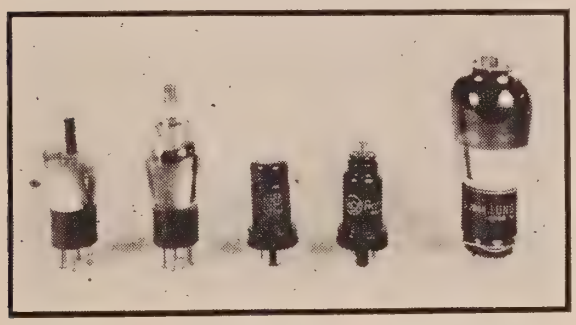
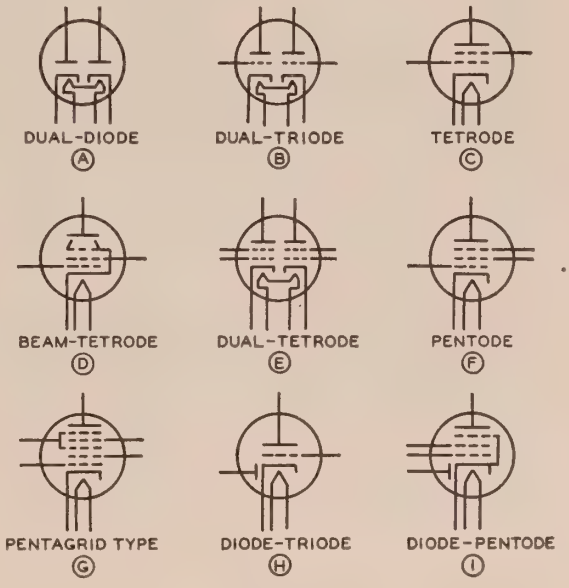


FIGURE 37

Receiving tubes. Left to right: single-ended glass type, double-ended glass type, single-ended metal type, double-ended metal type, single-ended glass type power amplifier.

Figure 37 shows a group of tubes representative of the various types. The first is a single-ended glass tube with 5-pin base, the second a double-ended glass type with 7-pin base, the third a single-ended metal tube with 8-pin (octal) base, the fourth a double-ended metal tube with octal base, and the last a single-ended glass tube with octal base.



TUBE SYMBOLS

FIGURE 38

CHAPTER THREE

How Radio Signals are Sent and Received

A radio transmitter is a device for generating radio waves to be sent through space. The *intelligence* conveyed may be either sounds such as voice or music, a facsimile picture or a television image, or it may be a telegraph signal. A radio receiver is a device for taking the intelligence from these waves and converting it into a usable form. Both transmitter and receiver require antennas for their operation. The transmitting antenna sets up radio waves in space (or, as it often incorrectly is said, "in the air"). The receiving antenna intercepts passing waves and converts them into alternating currents which are delivered to the receiver. While it is possible to carry on communication over distances of a few hundred feet or more without either transmitting or receiving antenna, reliable contacts over practical distances require the use of both antennas, even though the receiving antenna may be a small "loop" antenna.

Telegraph Transmitter The simplest arrangement for radio communication is shown in Figure 39. Here, the transmitter consists of a simple *oscillator* and the receiver is a simple *detector*. An oscillator is a vacuum-tube circuit for generating high-frequency currents. A detector may use a vacuum tube or a rectifying crystal to convert the received high-frequency currents into pulsating direct currents useful in the headphones.

In Figure 39, a telegraph key is used to start and stop operation of the transmitter. When the key is in its up position, the transmitter is "off the air" entirely. If the key is held down for a short interval of time, a short, continuous "train" of radio waves leaves the transmitting antenna. Conversely, if the key is held down for a long time interval a long train of waves is transmitted. As these wave trains impinge upon the receiving antenna, they actu-

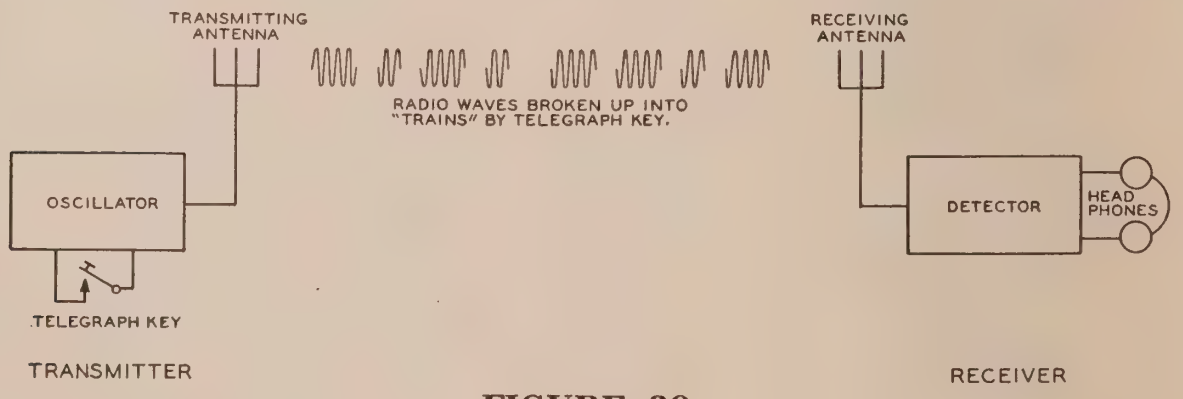


FIGURE 39

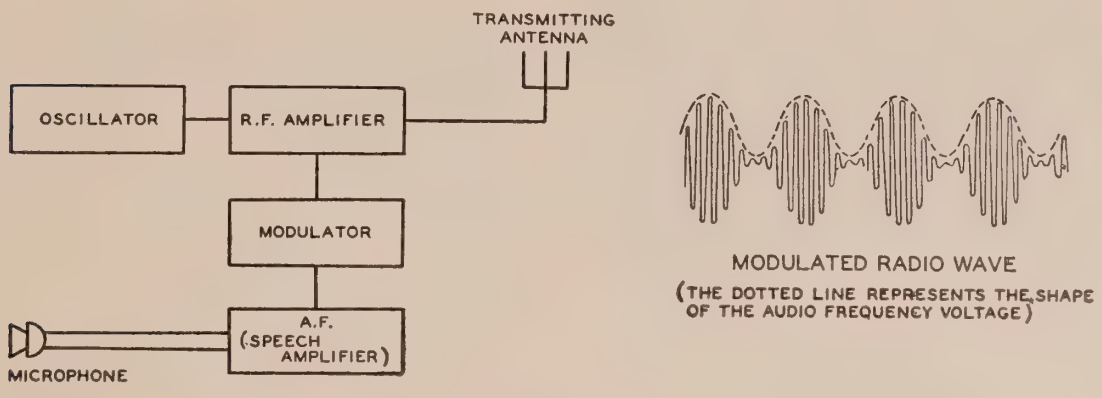


FIGURE 40

ate the receiver for corresponding long and short intervals. Long and short buzzes, hisses, or whistles accordingly are heard in the headphones, depending upon the type of receiver and the nature of the transmitter plate supply. We are able to carry on radiotelegraphic communication with a system of this sort by means of the Morse code which assigns to each letter of the alphabet, numeral, and punctuation mark a distinguishing combination of short sounds (dots) and long sounds (dashes).

Because the waves flow in a smooth, continuous, uninterrupted manner as long as the key is depressed, if a direct current plate supply is employed, this system is known as *continuous wave telegraphy*—abbreviated *C. W.*

The simple oscillator type of transmitter shown in Figure 39 may be *modulated* in various ways for radiotelephony, but is unlawful for voice transmissions except on amateur frequencies higher than 100 megacycles.

Radio-Telephone Transmitter A radiotelephone transmitter is shown in block diagram in Figure 40. Here, the oscillator (as in Figure 39) generates radio waves in the assigned frequency band of the station. These waves, in this case termed the *carrier*, are built up to a larger power level (amplified) by the r-f amplifier.

The microphone picks up sound waves and converts them into small pulsating or alternating voltages which correspond in vibration rate to the sound waves. The feeble microphone voltages then are amplified by the audio-frequency (speech) amplifier and are delivered greatly strengthened to the modulator which simply is a more powerful audio-frequency amplifier.

The modulator in turn feeds the audio-frequency voltages, which it has strengthened several thousand times or more in power, to the radio-frequency power amplifier where they are mixed with the outgoing radio waves. This mixing process is termed *modulation*.

Modulation carried on in this manner has the effect of molding the transmitted radio wave into the shape of the alternating audio-frequency voltage. (See the wave diagram in Figure 40.) When the modulated wave reaches the receiver, its audio-frequency portion is separated from its radio-frequency portion and reproduces the original sound by way of the headphones or loudspeaker.

Oscillator-Amplifier C-W Transmitter A radio- frequency power amplifier may be added in the same way as indicated for radiotelephony to the simple oscillator type of c-w telegraph transmitter shown

in Figure 39. In addition to greater transmitted power, more stable operation is obtained. The oscillator-amplifier type of transmitter is as desirable for c-w telegraphy as for radiotelephony. Its arrangement will be the same as the block diagram in Figure 40, except that the modulator and a-f amplifier are not used with telegraphy.

For very stable operation of either c-w or radiotelephone transmitters, it is desirable to include one or more additional r-f power amplifiers between the oscillator and the amplifier that feeds the antenna. When this is done, the last amplifier becomes known technically as the *final amplifier*, and the intermediate amplifiers are called *buffers* when they do not change oscillator signal frequency. If the intermediate amplifiers have the additional function of doubling, tripling, or quadrupling the oscillator signal frequency, they become known as *frequency multipliers* or as *doublers, triplers,* or *quadruplers,* as the case may be.

Complex Receivers While the simple receiver consisting of a detector only, as indicated in Figure 39, serves to illustrate the principle of radio reception, it seldom is employed today except in emergencies when no other type of receiver is available. This rudimentary receiver is not sensitive to weak signals and the sounds heard in the headphones are somewhat weak even when the picked up signal is fairly strong. At the same time, the simple detector is not *selective.* That is to say, it does not separate desired and undesired signals efficiently, and it is not fully responsive to pure c-w telegraph signals.

In order to make c-w signals fully audible and intelligible at the receiving station, it is necessary to mix in with them a locally-generated continuous r-f signal. Two ways of doing this are shown in Figure 41. In 41-A, a local r-f oscillator is connected to the input end of the detector, together with the receiving antenna, so that the detector receives both incoming antenna signal and the signal generated by the local oscillator. If the oscillator is tuned to a frequency slightly higher or lower than the signal frequency, an audible *beat note* will be set up as a result of interaction between the two frequencies. This note is audible in the headphones only for the duration of a dot or dash wave train. The beat frequency takes the form of a whistle which may be adjusted to the most pleasing tone or pitch simply by varying the local oscillator frequency. This scheme is known as *heterodyne reception.*

Heterodyne reception in the manner just illustrated requires the use of an

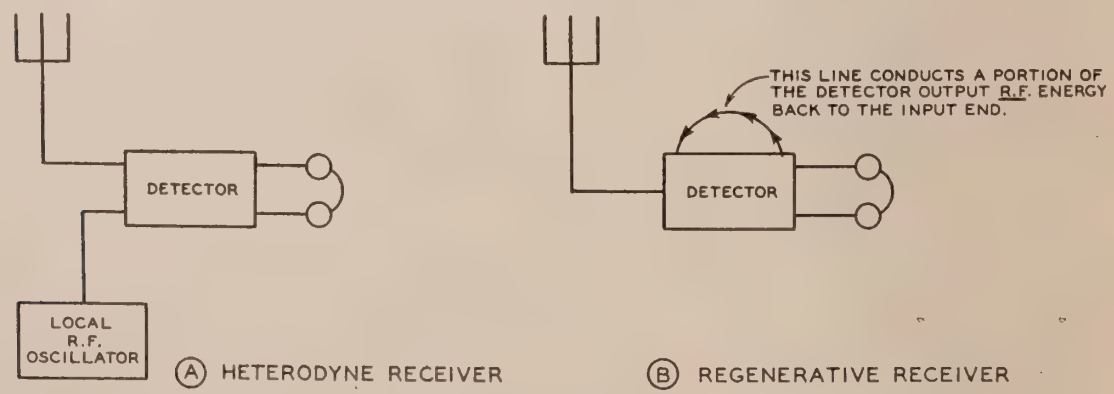

DETECTOR
LOCAL R.F. OSCILLATOR
(A) HETERODYNE RECEIVER
THIS LINE CONDUCTS A PORTION OF THE DETECTOR OUTPUT R.F. ENERGY BACK TO THE INPUT END.
DETECTOR
(B) REGENERATIVE RECEIVER

FIGURE 41

additional receiver stage—the local beating oscillator. The same effect may be accompished by taking a portion of the detector's r-f output voltage and feeding it back (by coil or capacitor coupling—See Chapter 2) to the detector input so that the detector itself oscillates. In this way, the detector itself supplies the r-f voltage required to set up the beat note with the incoming signal. A detector arranged in this manner is said to be *regenerative*. Such a receiver is termed an *autodyne*. Renegeration greatly increases the receiver sensitivity and selectivity.

A weak signal received by the antenna may be strengthened by means of a vacuum-tube amplifier stage placed between the antenna and detector. Because such a stage amplifies the radio-frequency voltages before they reach the detector, it is termed a *radio-frequency amplifier*. Likewise, a weak audio-frequency signal delivered by the detector may be strengthened by means of a similar amplifier stage placed between the detector and headphones (or loudspeaker). Because of its function, this latter stage is termed an *audio-frequency amplifier*. Figure 42 shows a receiver arrangement employing both types of amplification.

For best results the r-f amplifier, as well as the detector, must be tuned to the frequency of the incoming signal. In order to simplify the simultaneous tuning of r-f amplifier and detector stages, *tuned r-f receivers* of this type are provided with a single dial which adjusts both stages. This scheme receives the name *ganged tuning*.

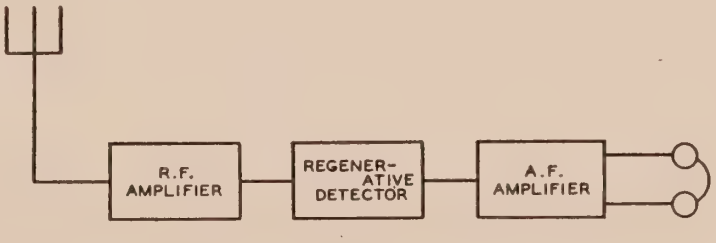
Several r-f amplifiers may be used, one after the other, to build up a weak radio signal successively. In the same manner, several a-f stages may be used to boost the audio signal voltages delivered by the detector. However, in practice we seldom employ more than two r-f and two a-f stages, because of operational difficulties introduced by larger numbers of amplifiers.

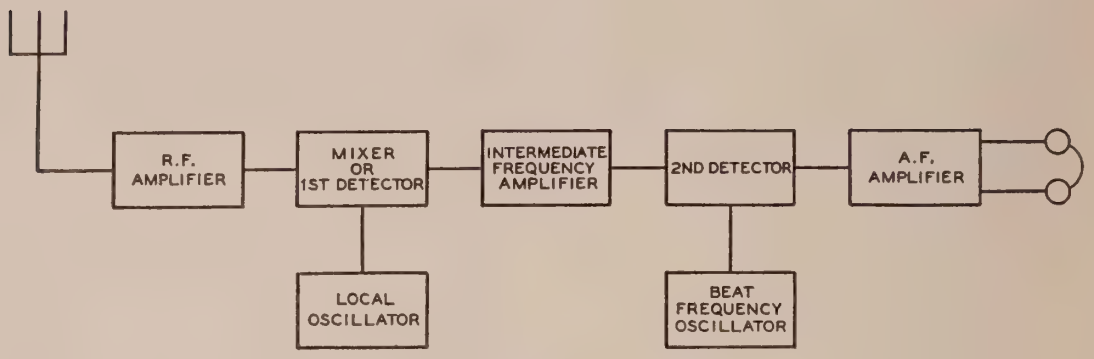
Receiver Tuning *Tuning*, or the setting of a receiver to a desired signal frequency, is accomplished with tuned r-f transformers or couplers. A conventional coupler such as is used for this purpose is shown in Figure 11 of Chapter 2. Tuning is carried on entirely by means of the variable capacitor. Some transformers of this type, especially those used in the intermediate amplifier of the receiver next to be described, employ variable capacitors to tune both primary and secondary coils.
coils.

Superheterodyne Receiver The most sensitive and most selective modern receiver is the *superheterodyne*. This type of receiver is equally effective in telephony and telegraphy. Figure 43 is a block diagram of the superheterodyne.

The efficiency of the superheterodyne results from its use of an *intermediate frequency amplifier*, represent-

FIGURE 42





SUPERHETERODYNE RECEIVER

FIGURE 43

ed by the third upper block in Figure 43. This amplifier is so named because it operates on a fixed low or "intermediate" radio frequency—such as 455 kc. The frequency of the highly efficient i-f amplifier is not changed as the receiver is tuned to a signal. Instead, it is set to the required intermediate frequency and left alone, and all signals picked up by the antenna have their frequencies converted to this intermediate frequency at which they undergo unusually efficient amplification.

How this signal conversion is accomplished is explained in this way: An incoming signal is amplified by the tuned r-f amplifier (1st upper block in Figure 43) and is delivered to the 1st detector. The latter also is called the *mixer* because it is in this stage that the incoming signal is mixed with a signal from a local oscillator (1st lower block in Figure 43). The local oscillator is tuned simultaneously with the r-f amplifier and detector (mixer) and is so adjusted that its frequency always is higher or lower than the signal frequency (usually higher) *by the amount of the intermediate frequency.*

Thus; when a 4000-kc. amateur signal is being received on a superheterodyne having an i-f of 455 kc., the local oscillator delivers to the mixer a signal equal to 4000+455, or 4455 kc. In the mixer stage, the incoming and local oscillator signals interact to produce an inaudible "beat note" signal equal to the difference between their two frequencies. This difference is always equal to the intermediate frequency regardless of the frequency of the incoming signal. Accordingly, the signal delivered by the mixer, being of the same value as the intermediate frequency, passes through the i-f amplifier with the large amplification of those stages.

The strengthened and sharpened signal delivered by the i-f amplifier still is a radio frequency and therefore inaudible. It cannot actuate headphones, loudspeaker, or a-f amplifier. So it again is "detected," or rectified, this time by the "2nd detector" (fourth upper block in Figure 43) and delivered to the a-f amplifier. In order to make a c-w telegraph signal audible, it must be heterodyned, as explained earlier in this chapter. In order to do this, a second local oscillator (2nd lower block in Figure 43) is coupled to the 2nd detector. The frequency of this *beat frequency* or *c. w. oscillator* is made a few hundred to a few thousand cycles higher or lower than the intermediate frequency, to produce audible whistles corresponding to the dot and dash wave trains. The pitch or tone may be adjusted to suit the ear of

the operator by varying the c. w. oscillator frequency. The c. w. oscillator is switched off during radiotelephone reception.

The superheterodyne receiver is a complicated set to build and is equally complicated to adjust before being placed into operation for the first time. Because of this, few amateurs attempt to build such a receiver, preferring to buy a factory-built superheterodyne designed for amateur use.

Transmitter Frequency Control In Chapter 1, the various bands of frequencies assigned for amateur use are listed. The oscillator stage of any amateur transmitter must initiate signals on one of these authorized frequencies. This is done in either two ways: (1) the oscillator circuit may be so arranged that its frequency may be set to various desired values by adjusting a variable capacitor connected to a coil of the proper inductance. An oscillator tuned in this fashion is termed a *self-excited* or *variable-frequency* oscillator. Or (2) a quartz crystal (See Chapter 2 for description), ground for one definite operating frequency, may be connected to the grid of the oscillator tube and used to set the oscillator frequency. This type of oscillator cannot operate on any other frequency unless another crystal is substituted in the circuit. It therefore is a fixed-frequency oscillator. This is the *crystal controlled oscillator.*

Crystal controlled transmitters are strongly recommended to the newcomer, since they are almost entirely foolproof. It is comparatively easy to tune a variable-frequency oscillator accidentally to a frequency outside of an authorized amateur band.

It was mentioned earlier that intermediate r-f amplifiers, or buffers, may be employed to multiply the frequency delivered by the oscillator in a transmitter. Amateurs find this particularly useful for arriving at a high frequency when using a low-frequency crystal for control. Since many amateur frequencies are multiples of others, it becomes possible, through frequency multiplication in the transmitter, to secure maximum utility from a given set of crystals.

Three examples of the use of frequency multiplying amplifiers in amateur transmitters are shown in the block diagrams in Figure 44. In 44-A, one doubler is inserted between the oscillator and final amplifier. With this arrangement, 7000-kc. operation can be obtained with a 3500-kc. crystal (or self-excited oscillator), 28,000-kc. operation with a 14,000-kc. crystal, etc. In 44-B, two doublers are employed. Here, we may start out with a crystal operating in the lowest-frequency amateur band, say 3500 kc., double to 7000 ks., and double again to 14,000 kc. A simpler way of accomplishing the same result is shown in 44-C. Here a single *quadrupler* is employed between the oscillator and final amplifier, to take the place of the two doublers.

In addition to the schemes shown, which might be carried out still further by the addition of still more doublers or quadruplers, it is possible to multiply the frequency in the oscillator stage and/or the final amplifier. Thus, an oscillator may be made to deliver two, three, or four times the crystal frequency, and a final amplifier may be made to deliver two, three, or four times the frequency delivered to it, though a reduction in efficiency and power output will occur, particularly with high orders of multiplication.

Multiplication in one stage of an amateur transmitter seldom is carried beyond quadrupling, since the efficiency of frequency multiplier stages drops rapidly and becomes impractical at higher multiples.

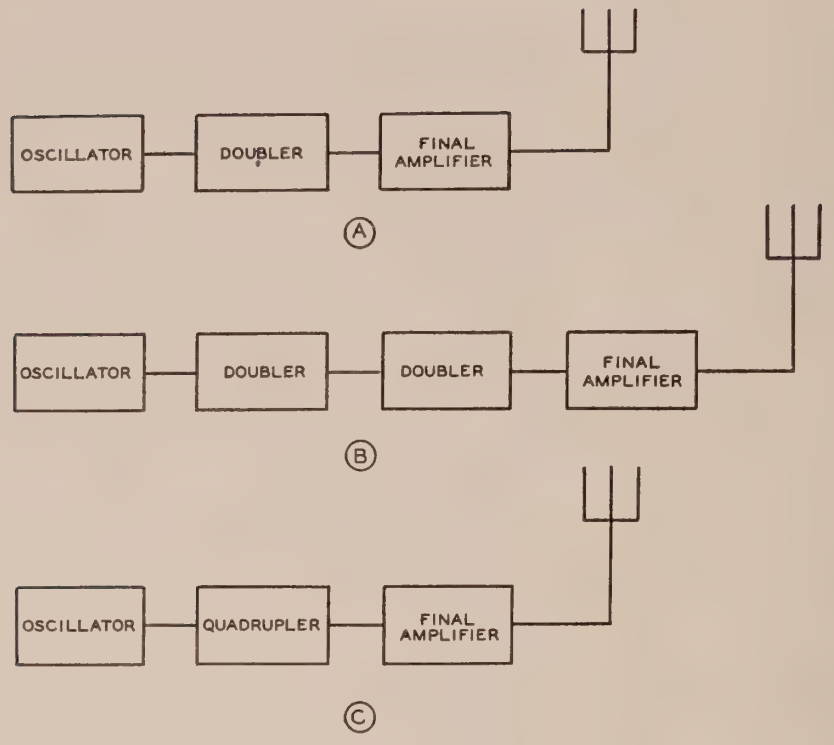


FIGURE 44

Power Supply Vacuum tubes are employed in each of the stages of a transmitter and receiver, except that silicon crystal diodes are sometimes used as mixers in super high-frequency receivers and germanium crystal diodes are sometimes used as second detectors. In order to operate, each vacuum tube must be supplied with an a-c or d-c voltage to heat its filament or heater, and d-c voltages for its screen and plate electrodes. All of these voltages are delivered by the *power supply* stage, not shown in the previous block diagrams.

For small portable transmitters and receivers, the power supply may consist entirely of batteries. In permanent installations, however, the voltages are obtained from the regular commercial a-c power lines through a transformer-rectifier arrangement. The line power is fed into the primary coil of an iron-core transformer having several secondaries. One of these secondaries delivers the low a-c voltage required to heat the cathodes. Another secondary heats the filament of a *rectifier* tube. Still another secondary supplies a high a-c voltage to the rectifier tube plates. The rectifier tube, in turn, converts the high a-c voltage into a high d-c voltage for the screens and plates of the transmitter or receiver tubes. A filter (See Chapter 2) is employed to smooth out the d-c voltage obtained in this manner.

Plate and screen voltages supplied to receiver tubes are never more than a few hundred volts, usually being between 50 and 400 volts. D-C plate voltages required by transmitting tubes, on the other hand, may be several thousand volts in high-powered transmitters.

CHAPTER FOUR

Learning the Code

The Radiotelegraph Code In radiotelegraphy, messages are transmitted and received by means of combinations of long and short sounds corresponding to letters of the alphabet, numerals, and punctuation marks. Telegraphy thus is a system of sound reading. In Chapter 3, we explained how radiotelegraph signals are sent and received.

It would be impossible to carry on radiotelegraphic communication between different countries without international agreement as to the meaning of the telegraph signals. We accordingly have an *International Morse Code,* sometimes also called the *Continental Code,* which is used throughout the world. This is not the same code employed in U. S. land wire telegraphy by such agencies as Western Union, but it is the only one widely used on the air. The only exceptions in radio are the secret codes employed by Governments and in certain private communications of a confidential nature. Figure 45 gives the International Morse Code in which you must learn to send and receive messages before you will receive your radio operator license.

Sound Not Sight Telegraphy is a sound system. Each letter, figure, and punctuation mark *must* be memorized by its code *sound* rather than by the appear-

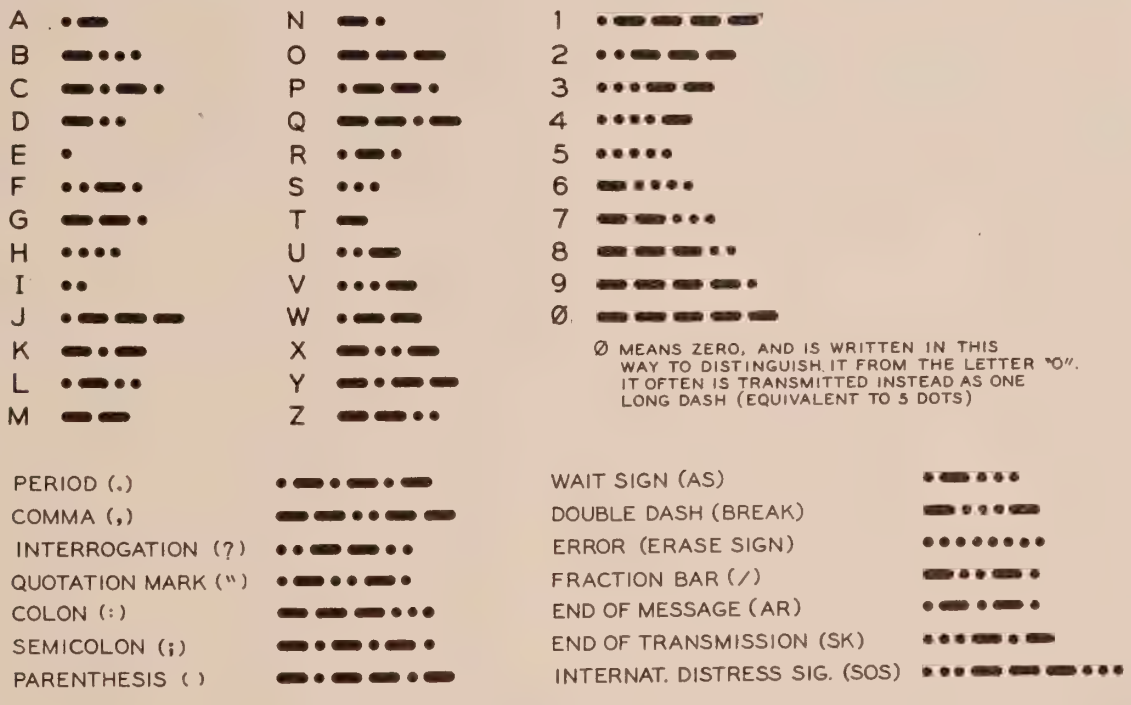


FIGURE 45

ance of corresponding code symbols. We call a short sound a dot but it sounds like *dit* when heard transmitted. The dash or long sound sounds like *dah*. The letter *A*, for example, is one short and one long sound in combination, sounding like *dit dah*, and it must be remembered in this way, not as *dot dash*. You will soon discover that all dots sound like "dit" and all dashes like "dah," whether these sounds are produced by a buzzer, electric bell, or by an oscillator through telephones or loudspeaker.

Memorizing the Code Where the code is concerned, there is no r o y a l road to learning. Relentless drill is the only method whereby anyone ever has committed this telegraphic alphabet to memory.

In studying the code, the best plan is to take a group of 3 or 4 letters at a time and to concentrate on them until they are thoroughly learned. Only when the first group is completely mastered should you pass along to the next group. And while working on a new group of letters, continue to review all groups that already have been learned. Unless you are gifted with a phenomenal memory, make no attempt to master the entire alphabet in one gulp.

Do not memorize the alphabet in rotation (A, B, C, D, etc). Be able to recall *any* letter already learned without having to think of its neighbors. Be able, for example, to sound the letter *M* as "dah dah," at a moment's notice, without having to run mentally through the *LMN* combination.

The code must be thoroughly memorized before starting to practice for code speed. You have not completed your learning job if you have to hesitate, even slightly, when asked to render any letter previously studied.

After you have learned the entire alphabet, together with numerals and common punctuation marks, get as many hours practice as possible translating mentally into dits and dahs every bit of printed matter that meets your eye. Use your newspaper, magazines, billboards, car ads, auto license plate numbers, etc. Use every available minute in this practice for several days and you will be surprised to find how soon you will have mastered the code completely.

If you are fortunate enough to have a companion who also is learning the code, you can have him talk to you in dits and dahs while you write down the letters corresponding to the uttered sounds. Change places frequently, allowing him to "receive" while you "transmit."

Code Practice You will have to develop a speed of 13 words a minute (5 letter words average) in both sending and receiving the code in order to pass the amateur radio operator license examination. To be doubly sure of passing this test, you should be able to receive 15 to 16 words a minute comfortably. Code speed can be developed only through constant practice.

Receiving practice can be obtained either by copying signals transmitted by another operator, by copying code transmissions direct from the air with a short-wave receiver, or by copying from a code practice machine.

If an experienced code man is available, he can transmit practice exercises for you, using a key and buzzer (or oscillator). Instruments for code practice will be described later in this chapter. You may build such equipment for yourself or you may purchase a key and buzzer set from a radio store, army surplus store, or Boy Scout supply house.

If you intend to "take" signals from the air, you should know beforehand that your code speed will have to be better than 10 words a minute before this even will be possible. Numerous commercial short-wave stations transmit daily news, radiograms, and other traffic continuously throughout the night, but their speeds average about 15 words a minute on "slow" transmissions. Many of these stations employ mechanical keying machines, so the speed of transmissions is accurately maintained. In some of the larger cities and towns, amateur stations voluntarily transmit code practice programs at progressive speeds. A request directed to your local amateur radio club, or to the American Radio Relay League, West Hartford, Connecticut, will bring a list of amateur code practice stations in your vicinity and information as to their hours of operation.

Code practice machines simply take the place of a human operator. They usually operate from long paper tapes along which the dots and dashes have been punched, and perform the task of automatically keying the oscillator or buzzer to which the student listens. Most code practice machines are driven by spring motors which are wound up like a clock or old-style phonograph, although a few of the more expensive models are supplied with electric motors. The code practice machine has the advantages that it can be set to a desired speed (number of words per minute) and is available at any hour it is needed. It has the disadvantage, however, that unless the owner has a sufficiently large number of tapes, he will run the risk of memorizing all of his practice material. This is surprisingly easy to do, even with a number of comparatively long tapes.

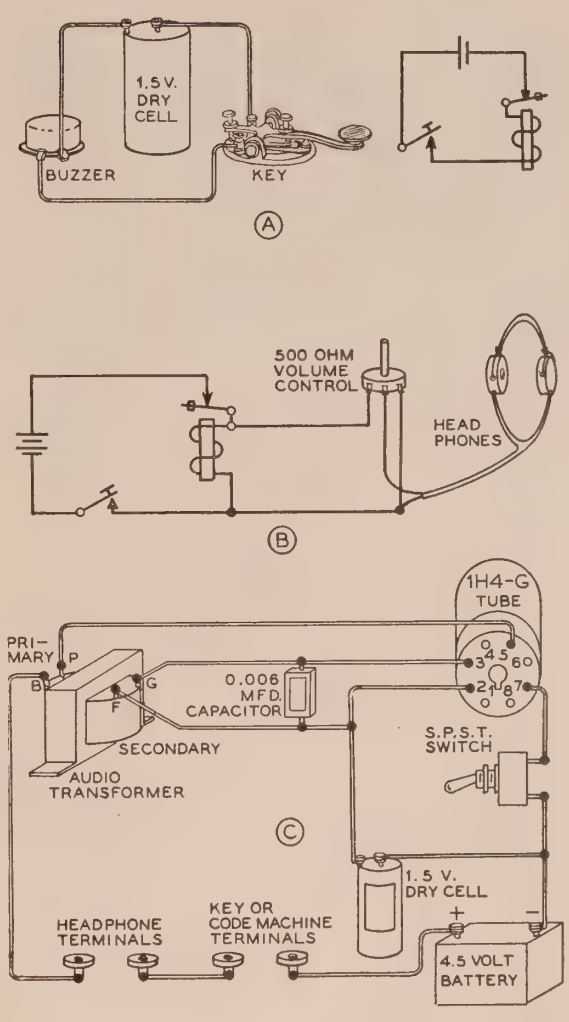


FIGURE 46

Code Practice Devices Figure 46 shows three popular types of code practice devices. In 46-A a key, buzzer, and dry battery are connected in series. The corresponding circuit diagram, with standard symbols, is shown to the right of the picture diagram. The receiving operator simply listens to the dots and dashes sounded by the buzzer as a result of manipulating the key.

This simple code practice set has the disadvantage that the buzzer can be heard at some distance and might prove disturbing to other persons. A better scheme is illustrated in Figure 46-B. Here, a quiet acting buzzer is used, and the listening is done through headphones. The headphones are pro-

vided with a volume control, in order that the operator may adjust the loudness of the signals to suit his ear. The volume control and headphones are connected across the *coil* of the buzzer, as shown in Figure 46-B.

The code practice set shown in Figure 46-C is an oscillator. This type is favored by most students. The unit uses a small dry-cell-type radio tube, two dry batteries, and an audio transformer as the main parts. Connections are made as shown in the sketch. When the key is depressed, a steady whistle should be heard in the headphones. If this "oscillation" is not obtained,, be sure that the positive (+) and negative (—) terminals of the batteries are connected as shown in the drawing. If these polarities are found to be correct, try reversing the primary terminals of the audio transformer. At the end of a practice session, the single-pole, single-throw switch is thrown to its OFF position to place the tube and batteries out of operation.

Any of the code practice devices shown in Figure 46 may be used in conjunction with a code practice machine simply by connecting the machine in place of the hand key.

Keys Two types of keys are employed in amateur radio—the plain hand key and the semi-automatic key, known familiarly as a "bug."

All characters must be formed singly with the hand key which is depressed for a short interval of time for each dot and held down three times as long for each dash. Standard telegraph keys of this type are operated by means of an up and down motion, although a few "side-swipers" are available which are operated back and forth from left to right.

The semi-automatic key is operated from side to side, like the side-swiper. Each dash is formed separately by pressing the key to the left. But when the key lever is pressed to the right, a whole string of dots is transmitted automatically, the speed of these dots being controlled by setting the position of the small weight on the far end of the lever.

We strongly advise newcomers to keep away from semi-automatic keys. These devices should be adopted only after the operator has had *long* experience with a regular hand key and has developed an unfailing sense of dot and dash length and spacing.

Using the Key Figure 47 shows the proper position of the hand, fingers, and wrist when manipulating a telegraph key. The forearm should rest naturally on the desk. The key must be placed far enough back from the edge of the table (about 18 inches) that the elbow can rest on the table. Otherwise, pressure of the table edge on the arm will tend to hinder blood circulation and weaken the arm.

The knob of the key is grasped lightly with the thumb along the edge; the index and third fingers rest on the

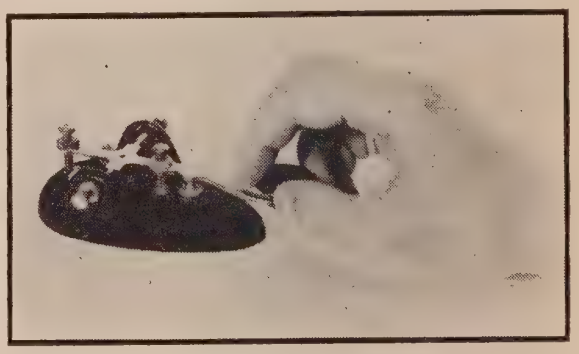


FIGURE 47

Proper method of grasping the key when sending code signals. The fingers touch only the rim of the knob, which is held just tightly enough to prevent slipping of the fingers—no tighter.

top towards the front or far edge. The hand moves with a free up and down motion, the wrist acting as a fulcrum. The power must come entirely from the arm muscles. The third and index fingers will bend slightly during the sending but not because of deliberate effort to manipulate the finger muscles. Keep your finger muscles just tight enough to act as a "cushion" for the arm motion and let the slight movement of the fingers take care of itself. The key's spring must be adjusted to the individual wrist and should be neither too stiff nor too loose. Use a moderately stiff tension at first and gradually lighten it as you grow more proficient. The separation between the key contacts must be the proper amount for the desired speed, being somewhat under 1/16 inch for slow speeds and slightly closer together (about 1/32 inch) for faster speeds. Avoid extremes in either direction.

Do not allow the muscles of the arm, wrist, or fingers to become tense. Send with a full, free arm movement. Avoid any finger movement whatever, except the slight cushioning effect mentioned previously. A good arm exercise is to practice sending a long series of dots, striving all the time for smoothness and evenness of spacing.

Remember that you are using different muscles from those you have used previously. Give them time to become used to the new demands which you put upon them.

Timing It is of the utmost importance to maintain uniform spacing in characters and combinations of characters. Lack of uniformity at this point probably causes beginners more trouble than any other single factor. Every dot, every dash, and every space must be correctly timed. Accurate timing is essential to intelligibility, and timing of the spaces between the dots and dashes is just as important as the lengths of the dots and dashes themselves.

The characters are timed with the dot as the "yardstick." A standard dash is three times as long as a dot. The spacing between parts of the same letter is equal to one dot; the space between letters is equal to three dots, and that between words equal to five dots. There is *no such thing* as long, medium, or short dashes; a dash must always equal the length of three dots, neither more nor less. A possible exception is the "long dash" used by some amateurs for the numeral zero, in order to save time.

The rule for spacing between letters and words is not strictly observed when sending slower than about 10 words per minute for the benefit of someone learning the code and desiring receiving practice. When sending at say, 5 words per minute, the individual letters should be made the same as if the sending rate were about 10 w. p. m., except that the spacing between letters and words is greatly exaggerated. The reason for this is obvious. The letter *L*, for instance, will then sound exactly the same at 10 w. p. m. as at 5 w. p. m., and when the speed is increased above 5 w. p. m. the student will not have to become familiar with what may seem to him like a new sound, although it is in reality only a faster combination of dots and dashes. At the greater speed he will merely have to learn the identification of the *same* sound without taking as long to do so.

Experience has shown that it does not aid a student in identifying a letter by sending the individual components of a letter at a speed corresponding to less than 10 w. p. m. By sending the letter moderately fast a longer space can be left between letters for a given code speed, thus giving the student more time to identify the letter.

There are no degrees of readability in signals. They are either right or wrong, and if they are wrong, it is usually irregular spacing or irregular dash length which make them so. If you find that you have a tendency toward irregularity, practice those characters which give you trouble no matter how long you must do so. Until they can be formed perfectly you are not ready for speed.

Be particularly careful of letters like *B* in which many beginners seem to have a tendency to leave a longer space after the dash than that which they place between succeeding dots, thus making it sound like *TS*. Similarly, make sure that you do not leave a longer space after the first dot in the letter *C* than you do between other parts of the same letter; otherwise it will sound like *NN*.

Figure 48 is a diagram illustrating the relative length of dashes and spaces compared to the dot.

Perfect Formation of Characters When transmitting with the code practice set to your partner, concentrate on the *quality* of your sending, *not* on your speed. Your partner will appreciate it and he could not copy if you speeded up anyhow.

If you want to get a reputation as having an excellent "fist" on the air, just remember that speed alone won't do the trick. Proper execution of your letters and spacing will make much more of an impression. Fortunately, as you become more even and accurate in your sending, your speed will increase automatically. Remember to see how *evenly* you can *send*, and how *fast* you can *receive*. Concentrate on making signals properly with your key. Perfect formation of characters is paramount to everything else. Make every signal right no matter if you have to practice it hundreds of times. Never allow yourself to vary even slightly from perfect formation, once you have learned it. Never mind how slowly you must send in order to be accurate. In the long run you will gain speed much more quickly if you have learned right, and you will never get much speed if you learn wrong.

If possible, have a good operator listen to your sending for a short time, asking him to criticize even the slightest imperfections.

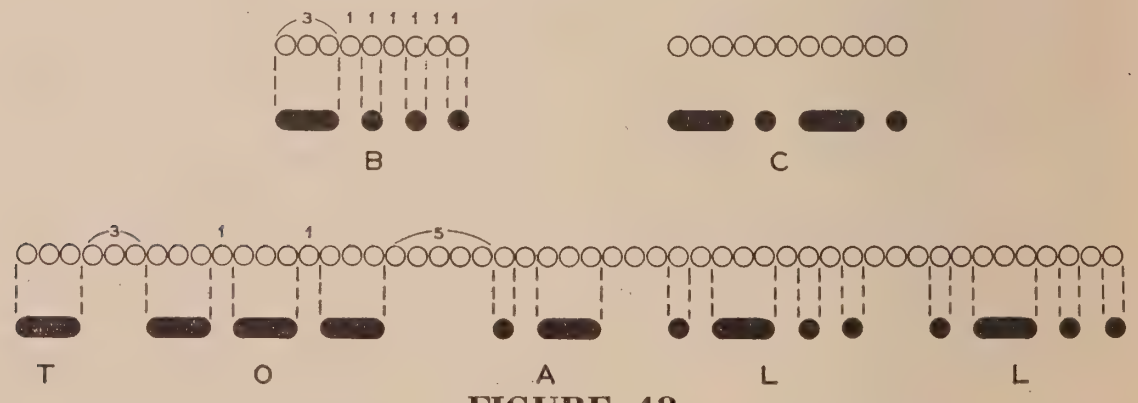
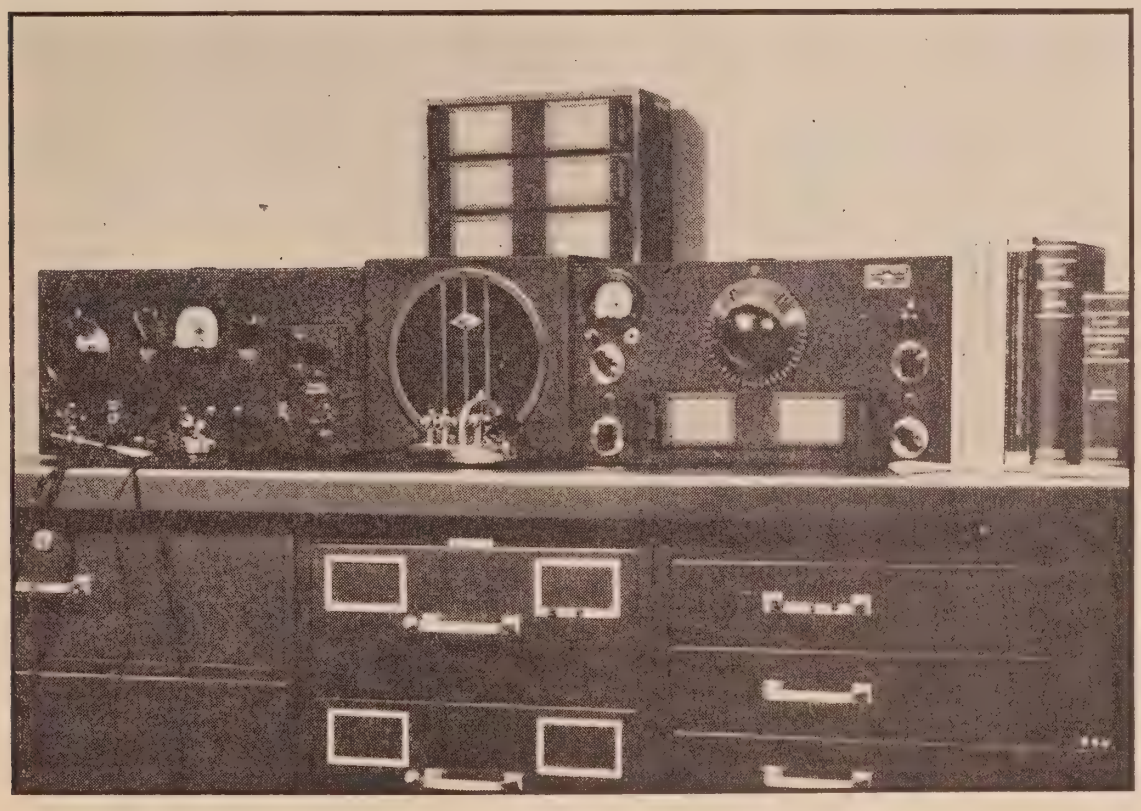


FIGURE 48

Diagram illustrating relative lengths of dashes and spaces compared to the dot. A dash is exactly equal in length to three dots; spaces between parts of a letter equal one dot; those between letters, three dots; space between words, five dots. Note that a slight increase in the space of a letter will make it sound like two different letters.

Practice Material When selecting text material for code practice, particularly when having someone send to you, make it a point to choose strange material. It is not necessary to select material printed in a foreign language, although this might be of great help, but you can take an article or story with which you are entirely unfamiliar. Little practice can be gained when you know exactly what letter or word is coming next. Transmitting regular text backwards is helpful, especially to the person receiving it. The element of uncertainty and surprise are desirable in receiving practice. Several hundred "words" that do not make sense, and that contain frequent figures as well as letters, make excellent material both for sending and receiving. Many words in one's own language, even the long ones, can be guessed after the first few letters have been transmitted, and for this reason artificial "words" are strongly recommended.



A neat amateur station. Transmitter on the left, loudspeaker in the center and receiver on the right. Plug-in coil assemblies for the receiver, in rear. Commercially made components. (National)

CHAPTER FIVE

Tools and Construction

You won't need an expensive collection of special tools in order to build a radio transmitter or receiver. You won't even need a workshop. To be sure, a shop is a convenience and fine tools, especially motor-driven ones such as a drill press, lathe, grinder, etc., have their advantages. You can build a perfectly satisfactory piece of radio equipment on the kitchen table with tools obtained at the "dime" store.

Essential Tools In radio work, as in any other craft, there are a few particular tools that are indispensable, unless one is willing to spend hours doing a job that could be done with the proper tool in a few seconds or minutes.

Essential radio tools are: light screwdriver, medium screwdriver, husky pocket knife, heavy "gas" pliers, long-nose pliers, cutting pliers or "diagonals," hand drill with at least 10 or 12 drills, and electric soldering iron.

Optional Extra Tools If the newcomer expects to do considerable radio construction work as he progresses in the art, he is advised to equip himself with a complete set of metal working tools. Only if he is completely equipped can he hope to turn out professional appearing apparatus with the minimum of labor.

In addition to the essential tools listed in the preceding section, the following tools are recommended: hacksaw; complete set of files (flat, round, and half-round) complete set of drills; machinist's hammer; center punch; scriber; small crescent wrench; complete set of hexagonal socket wrenches ("Spintites"); complete set of Phillips screwdrivers; complete set of Allen key wrenches; 1¼-inch and 1-⅛ inch tube socket punches; cold chisel; heavy bench vise; complete set of open-end wrenches; wire strippers; steel square; ⅜-inch and 1-inch taper reamers (square shank); and a carpenter's brace. Figure 49 shows a group of tools suitable for all ordinary radio construction work.

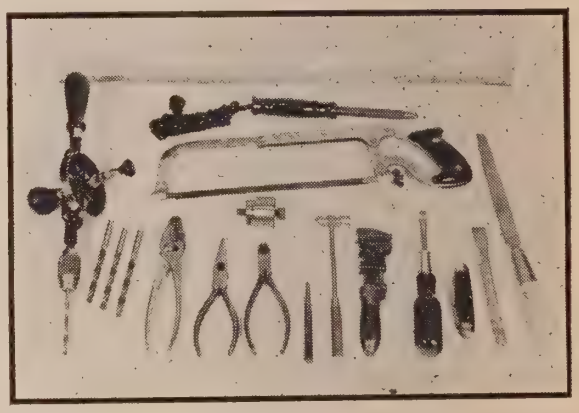


FIGURE 49
Tools for radio construction.

Optional Shop Equipment Aside from a workbench and a bench vise, already mentioned in the preceding section, the following equipment is recommended to the man who wishes to set up a modest shop for radio construction: drill press, ½-inch, floor or bench type; electric hand drill, ¼-inch; drill press vise;

motor-driven bench grinder; set of C-clamps; steel parallel bars (for simple sheet metal bending); oil stone; common sizes of machine screw taps and dies; carpenter's bits in commonly used sizes and one or two woodworking planes. It is doubtful that a lathe will be of sufficient aid to a man sticking strictly to radio building to justify the investment.

Essential Radio Materials Any radio instrument is only a collection of parts suitably mounted and wired together. The parts and the foundation (metal or wood) upon which they are mounted will be bought separately for each instrument or set. But certain working materials must be kept on hand for the building of each and every piece of equipment. These materials will constitute a working stock.

They include rosin-core solder; stranded and solid push-back hookup wire; No. 14 tinned copper bus bar; friction tape; soldering lugs; 1- and 2-terminal insulated terminal strips or "tie points"; rubber grommets; round-head machine screws and nuts (plated) in 4-36, 6-32, 8-32, and 10-32 sizes (several standard lengths up to 1¼"); binding posts or clip-type terminals; and an assortment of small metal washers.

Of course, many other materials might be added to this list, but the ones named are essential while most of those we have omitted will be used only once in a while.

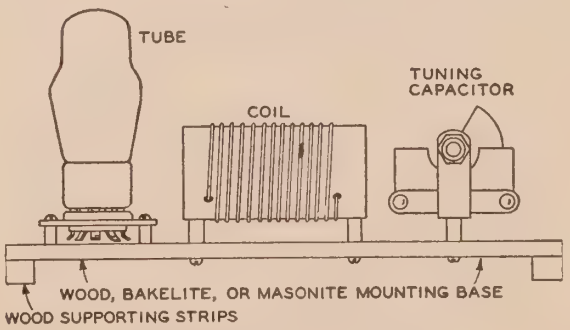
Types of Construction

Amateurs employ four general types of construction in building their transmitters, receivers, and test instruments. These are termed *breadboard, open chassis, panel and chassis,* and *enclosed cabinet.* We will give a brief description of each.

Breadboard This is the simplest possible type of permanent, rugged construction. Tube sockets, capacitors, resistors, and other parts are held by mounting screws to a flat wooden base which, because of its appearance, receives the name "breadboard." Breadboard type construction is illustrated by Figure 50. The same type of construction is shown in Figure 51, where the parts of a small crystal-type listening monitor have been mounted on a wooden base.

Wire leads may be connected between the parts on top of the breadboard (as shown in Figure 51) or, for purposes of concealment, may be carried under the base through holes drilled for the purpose. When wiring is run under the breadboard, it is advisable to mount a wooden supporting brace under each end of the base, as shown in Figure 50, in order to prevent electrical contact between the wiring and external metal objects finding their way under the base. Parts may be mounted both above and below the base, as desired.

In addition to wood, radio breadboards are made of Masonite, bakelite, or even of thick metal sheets with wooden supporting brackets. Non-metallic materials will be preferred by



BREADBOARD CONSTRUCTION

FIGURE 50

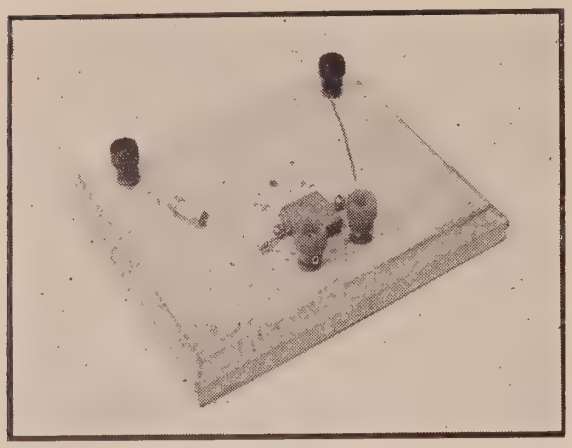
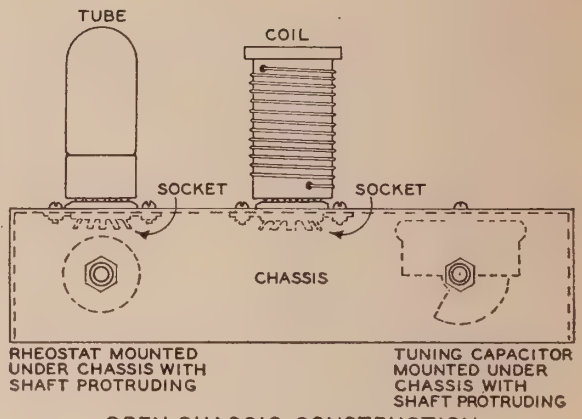


FIGURE 51
A crystal-type listening monitor, illustrating breadboard construction.



OPEN CHASSIS CONSTRUCTION

FIGURE 52

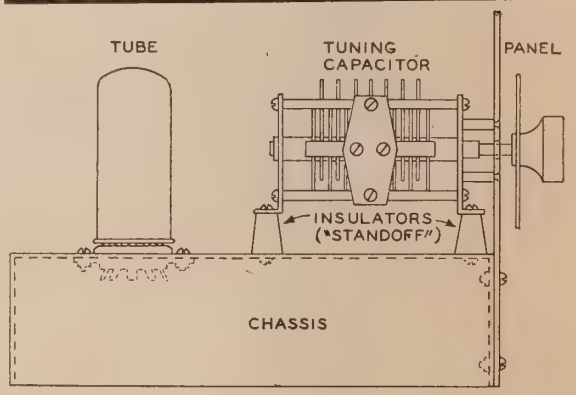
most amateurs for "breadboard" or "baseplate" construction. When metal is used, care must be taken to insulate the components from the metal base plate.

Open Chassis The parts may be mounted on a metal chassis instead of a wooden base board. Usually when employing such a chassis, it will be desirable to mount the parts "through the chassis" rather than to stand them on the top. Through-chassis mounting of the tube socket, for example, is accomplished by cutting a hole large enough to clear the socket terminals and then mounting the socket flat on the chassis with its terminals extending below chassis. Coils may be plugged into sockets similarly mounted. Variable capacitors, rheostats, etc. may be mounted below chassis with their tuning shafts extending through the front lip of the chassis. Binding posts usually are mounted through the rear lip. All metallic components carrying voltages are insulated from the chassis by means of suitable insulating mounting posts, washers, etc.

Figure 52 illustrates open chassis construction. This method has the simplicity of breadboard construction plus a certain amount of extra neatness of appearance and the rugged fireproof construction afforded by the use of metal. Also, the metal chassis provides some shielding and a good "ground-return." The ample height of the chassis permits mounting a number of parts underneath and doing all wiring below the surface. Metal chassis may be obtained in a number of convenient sizes at radio stores.

Several of the units shown in the transmitter chapter of this book are of the open-chassis type.

Panel and Chassis A front panel of metal, wood, or Masonite may be fastened to the chassis, as shown in Figure 53. This allows dials, knobs, switches,



PANEL AND CHASSIS CONSTRUCTION
SIDE VIEW

FIGURE 53

and other control devices to be mounted on the flat front face of the panel, giving a finished and pleasing appearance to the instrument and providing increased safety to the operator.

Several of the sets shown in the transmitter and receiver chapters of this book are of the panel-and-chassis type.

Figure 54 shows a metal panel and chassis assembly with all chassis and panel holes cut and ready for the mounting of parts. A sloping front panel has been used in order to allow easy tuning without bending or squatting to see the dial and meter readings.

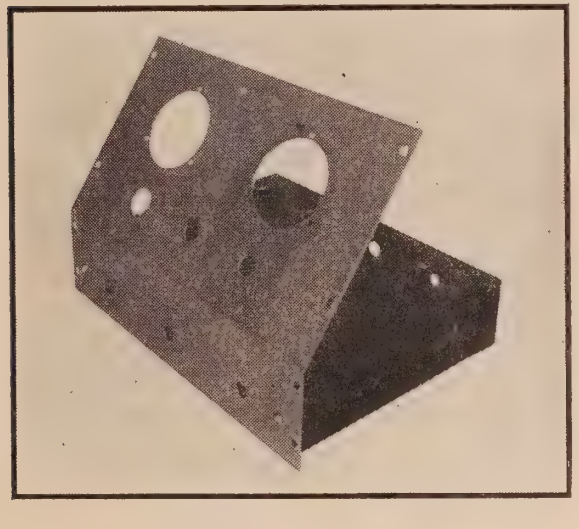
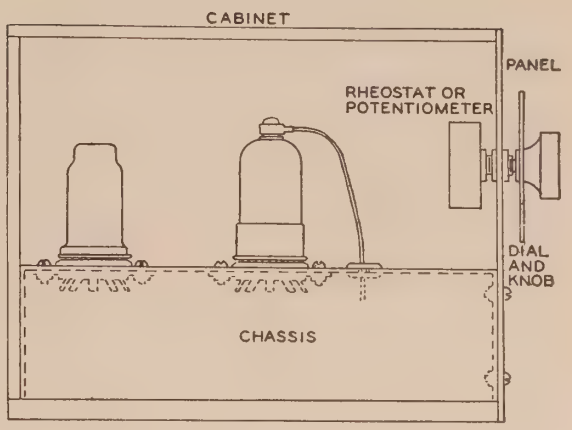


FIGURE 54
Illustrating metal panel and chassis type of construction. All holes have been cut and are ready for the mounting of parts.

Enclosed Cabinet Radio apparatus of the chassis and panel type, such as that shown in Figures 53 and 54, may be slid into a cabinet, usually metal (for good electrical shielding). This allows complete enclosure of the apparatus. Factory-built radio equipment almost always is of the enclosed cabinet type.

The cross-sectional drawing in Figure 55 shows the arrangement of parts in a typical enclosed cabinet set.



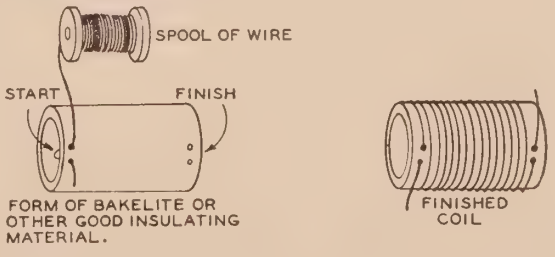
ENCLOSED CABINET CONSTRUCTION

FIGURE 55

Special Construction Methods

Construction of the newcomer's first equipment will be fairly simple. Because of this fact, we call attention here only to several constructional items which might offer somewhat of a problem to the newcomer. For additional information not in the scope of this book, the reader is referred to the chapter entitled *Workshop Practice* in the *Radio Handbook*.

Winding Coils Radio frequency coils used at amateur frequencies are small in size and do not have a large number of turns. They accordingly may be wound easily by hand. The method of winding a coil on an insulating form is shown in Figure 56. Here, two small holes are



WINDING COIL ON INSULATING FORM

FIGURE 56

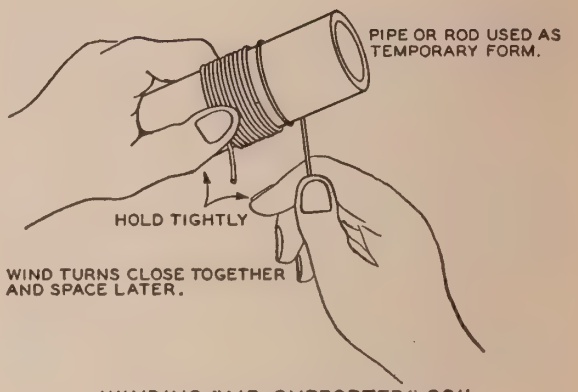
drilled about ⅛ inch apart at the starting point of the coil and two more where the last turn of wire will fall. These holes serve to anchor the wire. The wire is fed through each pair of holes in the manner shown in Figure 56.

In a coil of this type, the wire must be wound tightly and neatly. Before starting the winding, all kinks must be smoothed out of the wire. When directions call for a close-wound coil, each turn must touch its neighbor. Where a spaced winding is indicated, the turns must be wound with sufficient space between each one that the distance from the first to the last turn is the specified *winding length*.

Unless otherwise specified in the coil winding directions, insulated wire (enamelled or cotton-covered) will be employed in all coil winding.

Figure 57 shows the method of winding "self-supported" or "air-wound" coils. These coils have only a few turns, consequently can be made self supporting if fairly heavy wire is used. Coils of this type usually are specified for transmitter circuits operating from about 14 Mc. upward, and for both transmitters and receivers for ultra-high-frequency use.

A pipe or rod is used as a temporary supporting form while the coil is being wound. The proper number of turns is wound close together. After the winding is completed, one end of the coil is released, whereupon the coil will spring away from the pipe. Spacing of the turns finally is accomplished by gently pulling the two ends of the coil or by running a smooth rod, pencil, or strip between individual turns. The pipe or rod used for winding this type of coil must have an outside diameter slightly less than the required diameter of the finished coil, since the coil will spring out to a somewhat larger diameter than the temporary winding form.



WINDING "AIR-SUPPORTED" COIL

FIGURE 57

Cutting Socket Holes The job of cutting tube socket holes through a metal chassis is facilitated by the screw-type "knockout" punches now available at reasonable prices. One of these punches is shown directly under the hacksaw in Figure 49. Radio amateurs will need two punches to accommodate the various tube sockets available for receiving and small transmitting tubes—the 1¼" and 1-⅛" sizes.

Use of the punch is simple. First, a ⅜-inch hole is drilled through the chassis at the center of the proposed socket hole. Then the male portion of the punch is fastened into a vise (See Figure 58). Next, the punch screw is run through the female part of the punch and through the chassis hole (placing the female half on top of the chassis). Finally, after threading the screw into the vise-held male half of the punch, the punch is tightened by means of a wrench, as shown in Figure 58, until it bites completely through the chassis. This is a noiseless operation which permits clean holes to be cut quickly through sheet metal.

Socket holes may be cut also by means of a fly cutter, commonly called a "circle cutter," in a slow-running drill press. At fast speeds, the cutting tool may become burned, or it may chip, endangering the worker.

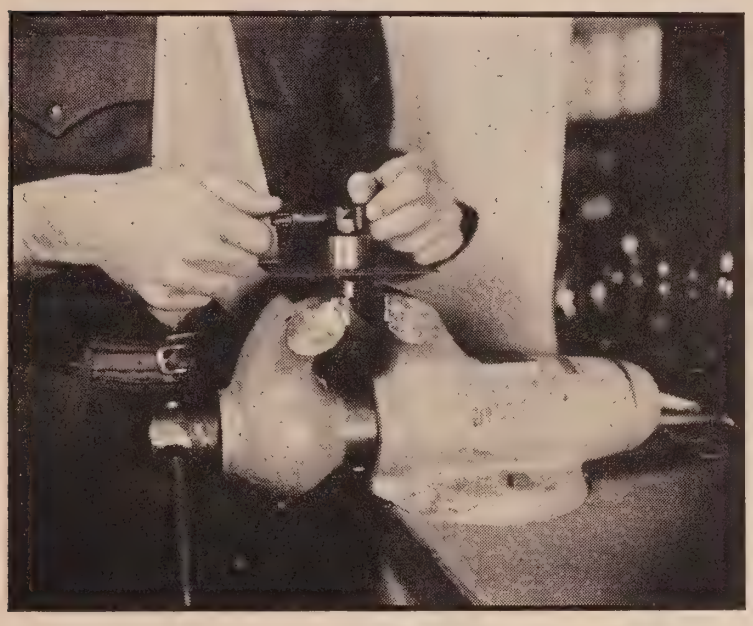


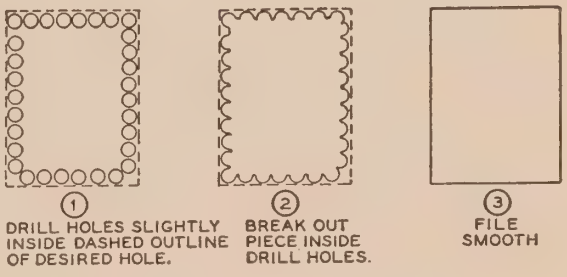
FIGURE 58
Cutting a round hole in a sheet of metal with the screw-type "knockout" punch. The male half of the punch is held in the vise; the female half above the metal plate which is to be cut. Pressure is applied by tightening the screw, as shown above.

Cutting Large Round Holes Meters, some dials, and large tubes require large round holes in the chassis or panel. These may be cut with a fly cutter, commonly called a circle cutter, in a slow-running drill press. An alternative method is to scribe the circle in the proper position on the chassis or panel, drill a number of small holes just inside the circle, cut through (as described for large rectangular holes in the preceding section), and file smooth. Punches similar to the socket hole punches previously described and illustrated are available in larger sizes to take standard size meters in the smaller sizes, but these punches are rather expensive in the "meter" sizes and their purchase is not justified unless one expects to drill lots of meter holes.

Cutting Large Square Holes Small transformers and chokes usually require large rectangular mounting holes which pose something of a problem to most newcomers. A few transformers have bunched wire leads which may be passed through small chassis holes, but these are the exception.

The simplest method of cutting a large hole of this type is illustrated by Figure 59. First, the outline of the required hole is scribed accurately on the chassis. Second, small holes are drilled close together just inside the outline. Next, the metal between the holes is cut out either with a hacksaw or cold chisel. Finally, the sharp teeth resulting from the cut-out operation are filed off, the filing being continued down to the rectangular outline.

Another method of cutting large rectangular holes consists of cutting along the scribed outline with a cold chisel and then filing the hole smooth.



MAKING RECTANGULAR CUTOUT

FIGURE 59

CHAPTER SIX

Amateur Radio Receivers

The newcomer's equipment need not be complicated. In fact, we encourage the beginner to start out with a simple outfit. After learning to manipulate a simple, inexpensive transmitter and receiver and to carry on amateur communication in the approved manner, he may progress to more complicated apparatus which he may either build or buy.

The newcomer's first home-made receiver should be a simple regenerative set, which may be designed for battery operation or for a-c power supply. A set of this type should be perfectly adequate for the beginner. Much can be gained by becoming expert in the manipulation of this type of receiver.

We do not encourage the newcomer to amateur radio to build a superheterodyne receiver. Even a small "simplified" superhet is a complicated device. Not only is it difficult to build a trouble-free model, but considerable skill and special test equipment are required to get it operating properly in the first place. The newcomer who really wants a superhet will do better to buy a factory-built model. Manufactured communication receivers are sold at various prices, some of them being priced right for the beginner with a short purse.

In this chapter, we describe receivers which may be built at home by the beginner. Simple wiring diagrams are presented. Photographs and drawings

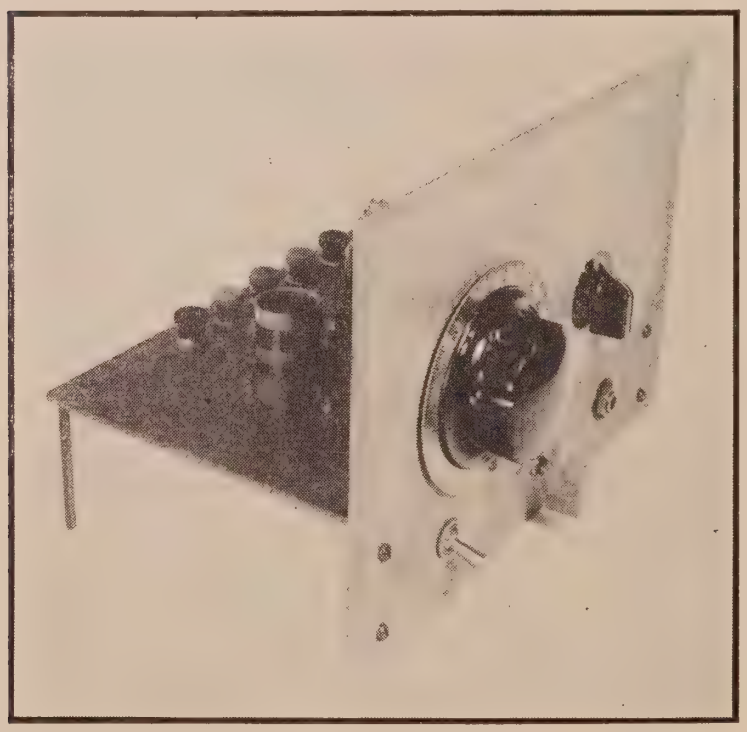


FIGURE 60
Overall View of the Regenerative Receiver.

complete the illustrative material. Follow the directions carefully and explicitly and little trouble will be experienced in getting these sets to give satisfactory performance.

2-Tube Regenerative Receiver

A simple two-tube regenerative receiver is illustrated by Figures 60 to 65 inclusive. While this receiver, as shown here is intended primarily for a-c operation (the recommended power supply unit is shown in Figures 66 to 70), it may be operated also from a 6-volt "A" battery and 180-volt "B" battery or from a 6-volt vibrator-type portable power supply. If resistor R_6 is shorted out, the receiver will work surprisingly well on a single 45-volt "B" battery.

The receiver employs a regenerative detector built around a 6J7 tube, and an audio amplifier with 6J5 tube. Loud signals are delivered to high impedance headphones (2000 ohms or over). The 10-, 11-, 20-, 40-, and 80-meter amateur bands are covered, and one simple antenna may be employed with excellent results on all bands.

Chassis and panel type of construction is used. If desired the receiver may be slid into a cabinet. The metal panel is 10 inches long and 7 inches high. The base of the set shown in the photographs is made of Masonite supported by wooden end strips. A number of amateurs, especially those accustomed to woodworking, will pick this arrangement. However, a metal chassis may be used if the reader desires.

The large round dial on the left hand side of the front panel rotates the main tuning capacitor, C_2. Bandset capacitor C_3 is controlled by the right-hand finger-grip knob which has been provided with a numbered scale for easy re-setting to the various amateur bands. The ON-OFF switch, S, may be seen almost directly under the main dial. The regeneration control potentiometer, R_5, is controlled by the finger-grip knob mounted in the lower center position on the front panel. Headphone jack J is in the lower right-hand corner of the panel.

The rear view of the receiver shows arrangement of the parts behind the front panel and on the chassis-base. Note that fixed capacitor C_4 and grid resistor R_1 are suspended by their leads in order to permit minimum possible length of the wire lead extending from

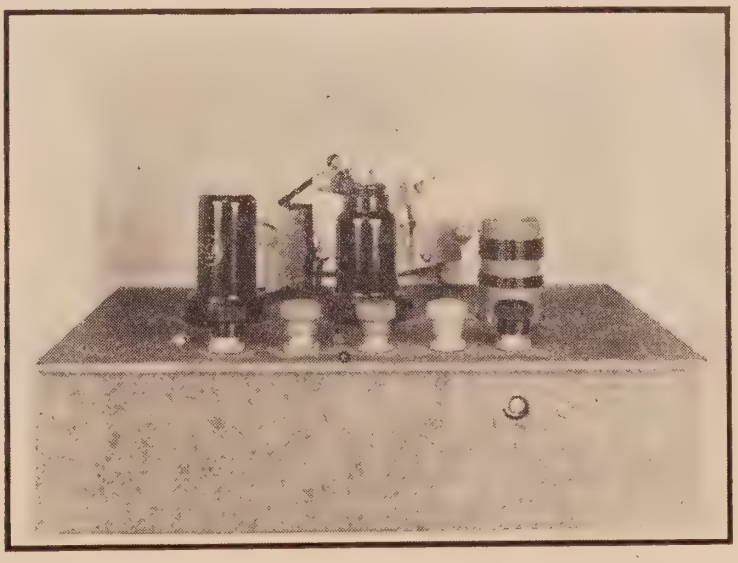


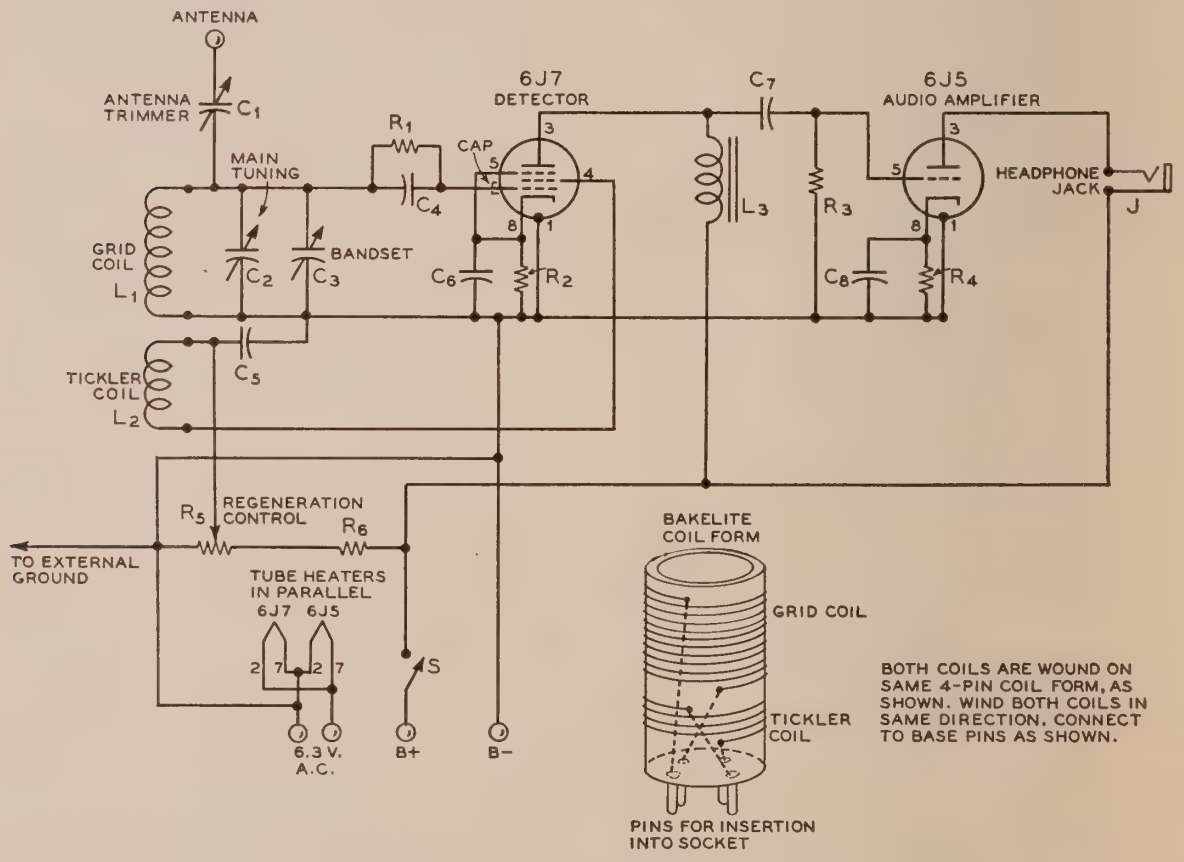
FIGURE 61
Rear View of the Regenerative Receiver.

them to the top of the grid cap of the 6J7 tube. A long grid lead will produce bad hum.

All terminal posts for connection to the power supply are mounted in a row along the rear edge of the base. The hole seen near the right hand end of the back lip of the chassis-base is for insertion of a screwdriver to adjust the antenna trimmer capacitor, C_1.

Four plug-in coils cover the 10-, 11-, 20-, 40-, and 80-meter amateur bands. Each of these is wound on a small 4- or 5-pin bakelite form. The mechanical arrangement of the coils is shown in the coil sketch in Figure 62. Coil winding instructions are given in Figure 65.

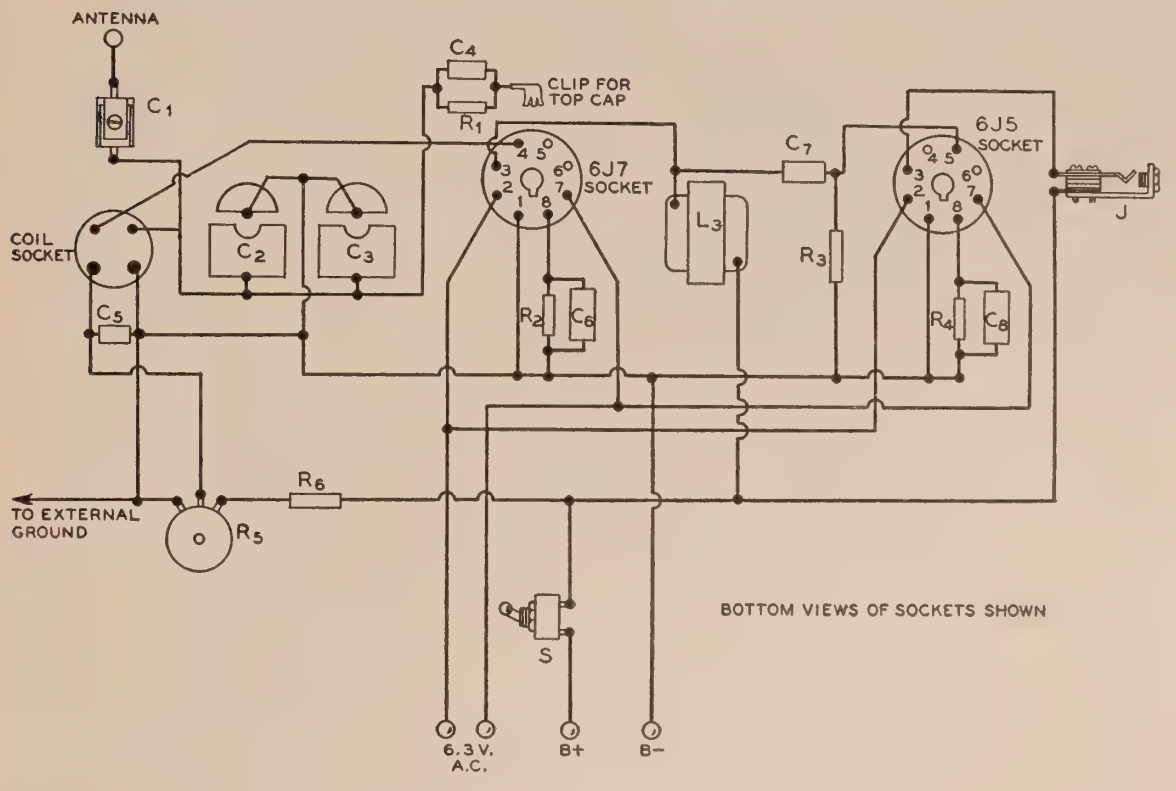
The schematic wiring diagram for the regenerative receiver appears in Figure 62. A corresponding picture diagram appears in Figure 63.



SCHEMATIC OF THE REGENERATIVE RECEIVER

FIGURE 62

C1—3-30-mmfd. compression-type trimmer capacitor
C2—15-mmfd. midget variable capacitor
C3—100-mmfd. midget variable capacitor
C4—250-mmfd. fixed capacitor, preferably mica
C5—0.001-mfd. fixed capacitor
C6—0.1-mfd. 200-volt tubular capacitor
C7—0.05-mfd. 400-volt tubular capacitor
C8—0.25-mfd. 400-volt tubular capacitor
J—Midget, normally-open phone jack
L1, L2—Plug-in coils for amateur bands (See Coil Table, Figure 65)
L3—Miniature audio choke, 200 henries or higher
R1—3-megohm ½-watt resistor
R2—300-ohm ½-watt resistor
R3—500,000-ohm ½-watt resistor
R4—1500-ohm 1-watt resistor
R5—50,000-ohm potentiometer
R6—10,000-ohm 1-watt resistor
S—Single-pole, single-throw toggle switch



PICTURE WIRING DIAGRAM OF THE REGENERATIVE RECEIVER

FIGURE 63

Power Supply A power-line-operated a-c power supply unit for the regenerative receiver is illustrated by Figures 66 to 70. This unit supplies 200 to 250 volts d-c and 6.3 volts a-c. Connections are made to the receiver by means of a 4-lead cable connected at one end to the terminals in the rear of the receiver, and at the other end to a 4-pin male plug which is inserted into the output socket of the power unit.

The power unit, employing open chassis construction (but easily enclosed in a metal case if the reader prefers), is built on a metal chassis 7" long, 6" deep, and 2¼" high. The power transformer, electrolytic filter capacitors, and type 80 rectifier tube are mounted on top of the chassis. The two filter chokes and bleeder resistor R are underneath. The ON-OFF switch, S, and the 4-pin output socket are mounted through one side lip of the chassis, and the a-c line cord enters the other lip through a hole which has been lined with a rubber grommet to keep the sharp edge of the chassis hole from cutting the cord.

After completing construction of the power unit, the line plug should be inserted into an a-c power outlet, switch S thrown ON, and a d-c voltmeter (set to its 500-volt range) connected temporarily between the B-plus and B-minus terminals of the output socket to test the d-c voltage. If all wiring is correct, this voltage should be between 200 and 250 volts, depending upon the high-voltage output of transformer T. An a-c voltmeter (set to its 10-volt range) may be used to check the 6.3-volt output.

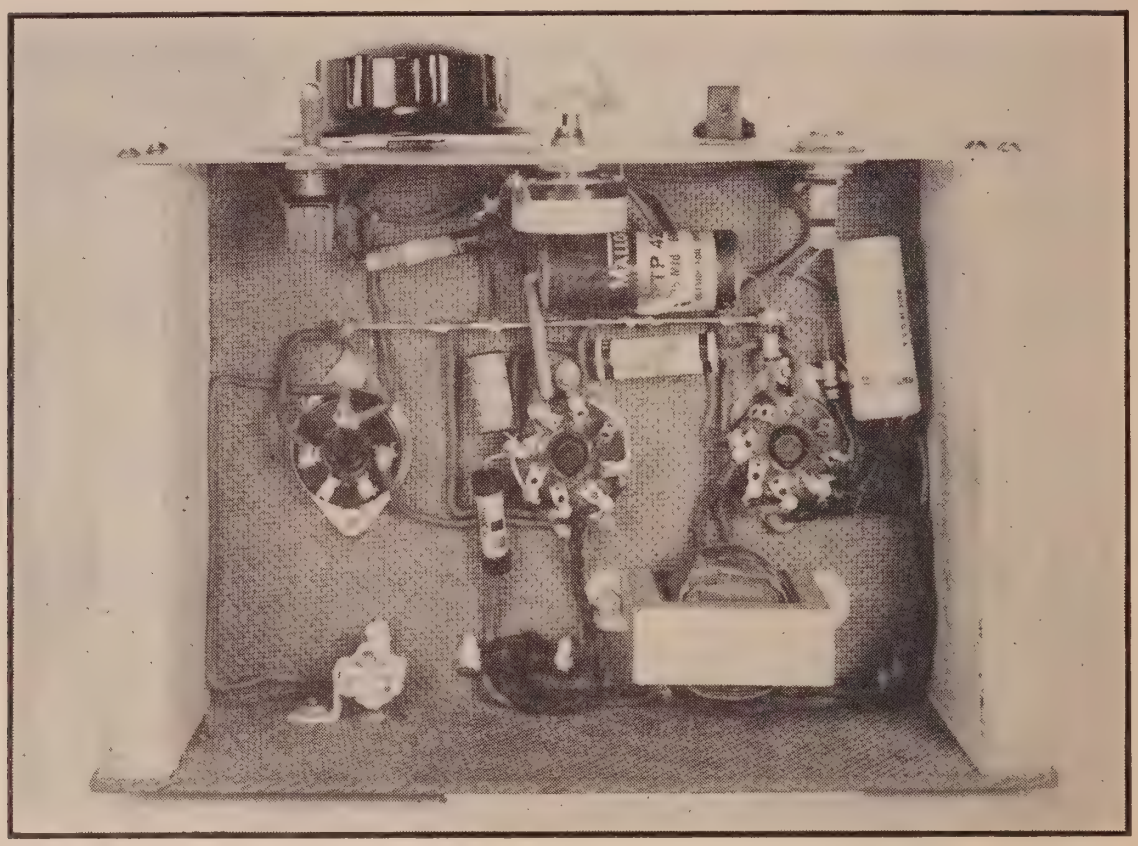


FIGURE 64
Under-Chassis View of the Regenerative Receiver.

Receiver Adjustment and Operation The following steps should be followed in testing and adjusting the regenerative receiver: (1) Connect 4-wire cable between receiver and power supply unit. (2) Plug 80-meter coil into coil socket of receiver. (3) Insert power supply line plug into 115-volt outlet and throw switch S in power unit to ON position. (4) After allowing a minute for all tubes to heat fully, insert headphone plug into jack J in receiver and throw switch S *in receiver* to ON position. (5) Set bandset capacitor C_3 to about half scale. (6) If test oscillator is available, feed unmodulated signal of 4000 kc. (top end of 80-meter band) into antenna terminals of receiver. (7) Make trial settings of regeneration control R_5, and adjust dial of main tuning capacitor, C_2 to tune-in signal which is heard as a clean whistle. (8) Record dial reading corresponding to 4000 kc. and repeat tuning procedure for a signal of 3500 kc. (lower end of the 80-meter band). (9) Note that pitch of signal may be controlled over a narrow range by means of regeneration control.

If a test oscillator is not available (radio repairmen own oscillators as standard equipment), an antenna and ground may be connected to the receiver and 80-meter signals tuned-in from the air. The two ends of the band then may be determined with fair accuracy by observing the points beyond which no more amateur signals appear. This is, of course, only an approximate method of determining the ends of the band.

FIGURE 65. COIL TABLE

3500-4000 kc. (80-meter band)

L1—50 turns No. 24 enamelled wire close-wound on 1"-diameter form.

L2—20 turns No. 30 enamelled wire close-wound close to bottom end of L1 and on same form.

7000-7300 kc. (40-meter band)

L1—16½ turns No. 22 enamelled wire on 1"-diameter form, spaced to winding length of ¾ inch.

L2—8 turns No. 30 enamelled wire close-wound ⅛" from bottom end of L1 and on same form.

14,000-14,400 kc. (20-meter band)

L1—10 turns No. 22 enamelled wire on 1"-diameter form, spaced to winding length of ¾ inch.

L2—6½ turns No. 22 enamelled wire close-wound ¼" from bottom end of L1 and on same form.

28,000-29,700 kc. (10-meter band)

L1—4½ turns No. 22 enamelled wire on 1"-diameter form, spaced to winding length of ¾ inch.

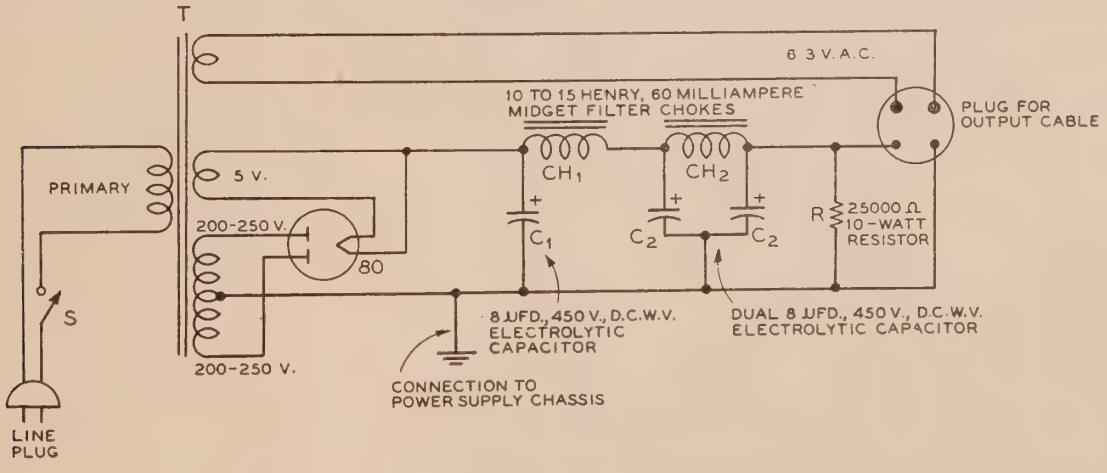
L2—3 turns No. 22 enamelled wire close-wound 3/16" from bottom end of L1 and on same form.

The 10-meter coils will also tune to the 11-meter band (27.185-27.455 Mc.).

Grid coils (L1) and tickler coils (L2) are wound in the same direction.

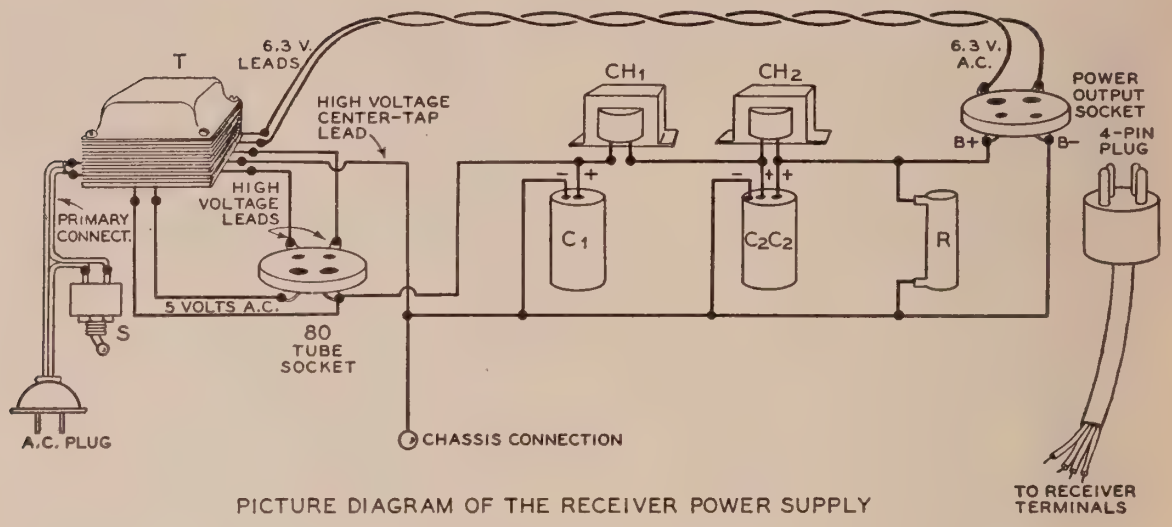
FIGURE 66
A. C. Power Supply for the Receiver.

The entire operation described in steps (1) to (9) must be repeated on the 10-, 20-, and 40-meter bands with the corresponding coils plugged into the coil socket. The frequencies corresponding to the ends of each amateur band may be found in Chapter 1 of this book. For 40 meters, bandset capacitor C_3 must be set at about three-quarters maximum; for the 10-and 20-meter bands with the rotating plates turned farther out: half-scale or less. The exact settings of C_3 must be determined by experiment, since they will vary in individual receivers. The correct setting will be one which spreads



SCHEMATIC OF THE RECEIVER POWER SUPPLY

FIGURE 67



PICTURE DIAGRAM OF THE RECEIVER POWER SUPPLY

FIGURE 68

the amateur band over most of the main tuning dial.

The antenna trimmer capacitor C_1 must be set so that the antenna has little detuning effect upon the receiver. Also, control R_5 must always be set for the lowest amount of regeneration necessary for good reception. Beyond a certain point in the setting of this potentiometer, the receiver will break into audio oscillation, setting up a steady howl in the headphones.

When using batteries for plate supply, be sure to turn off switch "S" when through with the receiver, or else the drain through the potentiometer will waste the batteries. With the a-c power pack it will suffice to simply turn off the a-c switch on the pack.

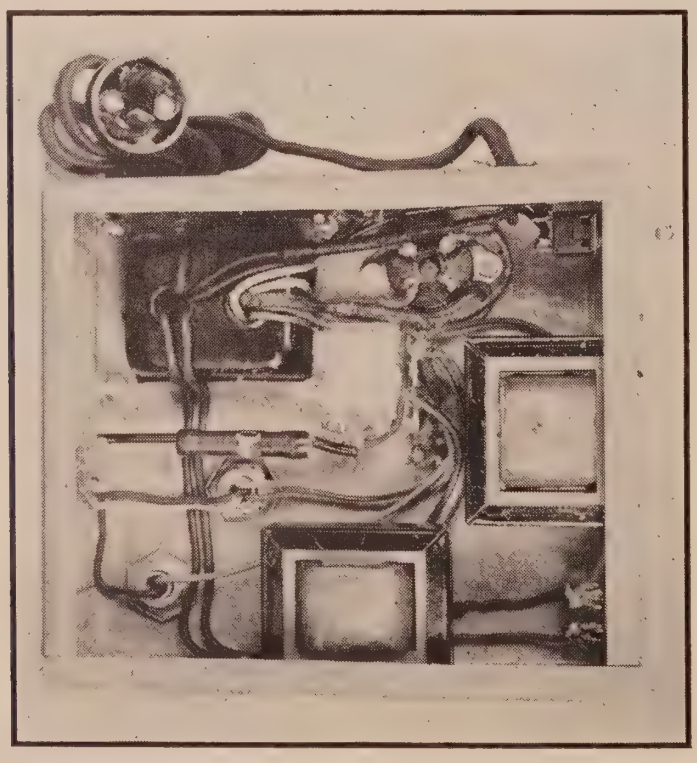


FIGURE 69

Under-Chassis View of the Power Supply.

FIGURE 70
Rear View of the Power Supply.

Ultra-High-Frequency Receiver

Many newcomers will be attracted to class-B radiophone operation in the 2- or 6-meter band. The compact superregenerative receiver illustrated by Figures 71 to 76 inclusive may be built to operate in either one of these bands. The set employs an HY615 tube as the superregenerative detector and two metal tubes as audio amplifiers. Loudspeaker operation is provided.

The superregenerative receiver is built on a 7″x7″x2¼″ chassis and a 6″ high by 7″ long panel. A cabinet may be used if complete enclosure is desired.

There are only two controls: a main tuning dial, and a regeneration control which also serves as volume control. The regeneration control knob is directly under the main dial, where it may be seen clearly in Figure 71. The jack to the left of the regeneration control receives the plug of a permanent magnet type dynamic loudspeaker.

The layout of parts is clearly visible in the photographs Figures 72, 75, and 76. The two coils (L_1 and L_2), tuning capacitor C_1, and radio-frequency choke RFC_1 are mounted back of the panel directly behind the main tuning dial and as close to the top-cap terminals of the HY615 tube as possible. This construction results in short leads, so important in successful ultra-high-frequency apparatus. The antenna terminals are mounted on a small polystyrene strip supported from the rear

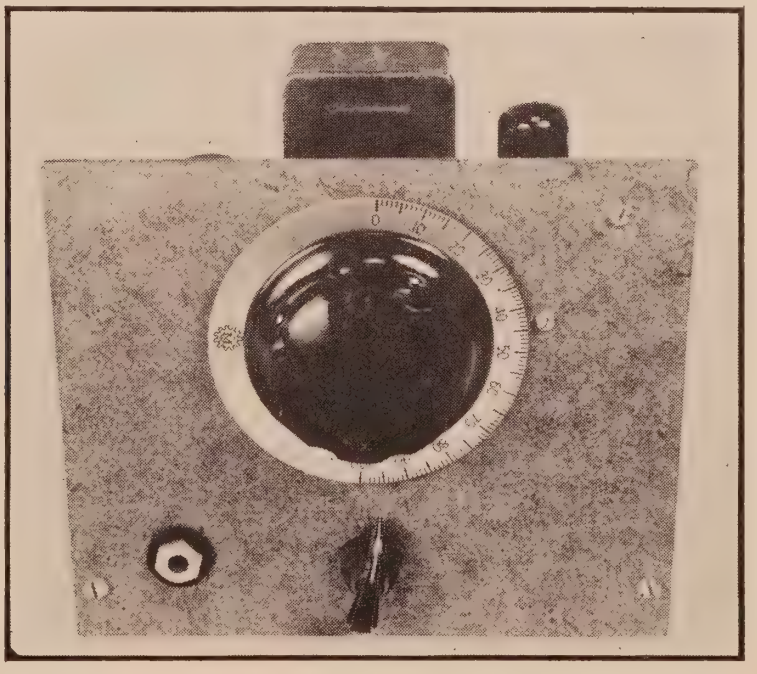


FIGURE 71
Overall View of the Superregenerative Receiver.

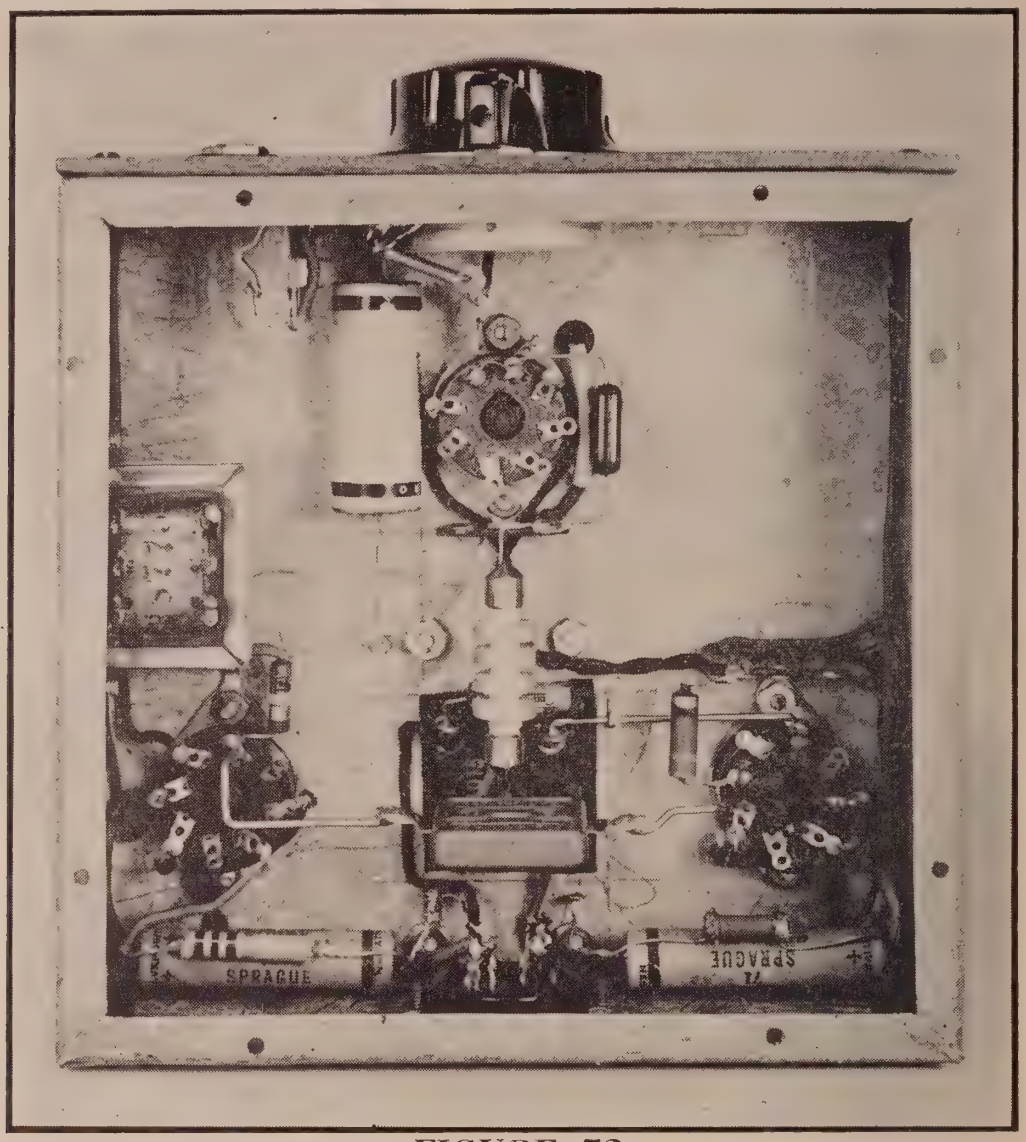


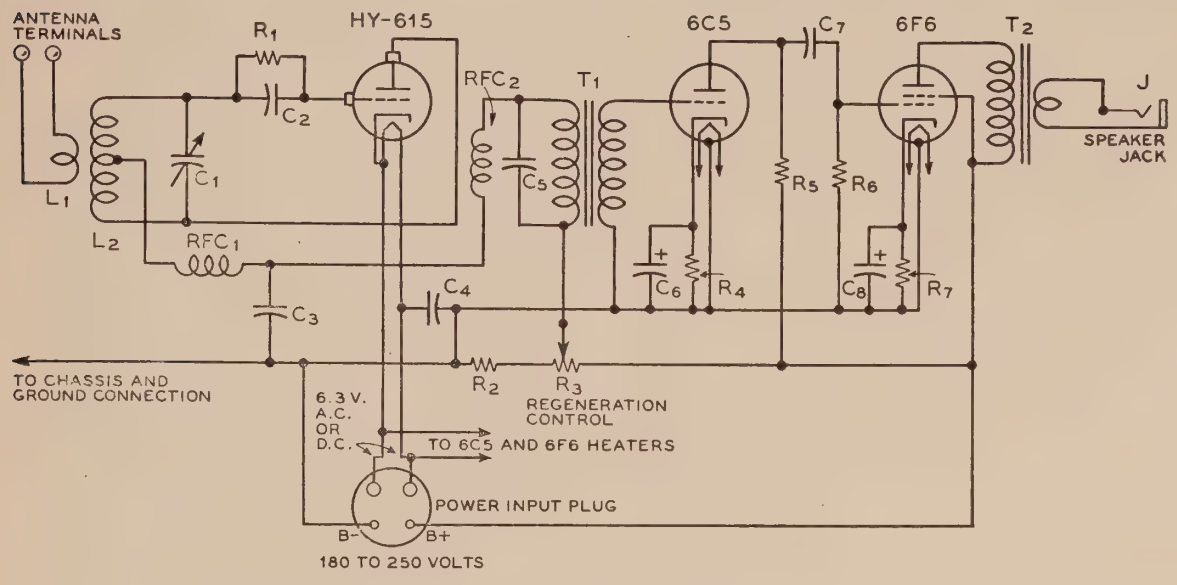
FIGURE 72
Under-Chassis View of the Superregenerative Receiver.

corner of the front panel (See Figures 75 and 76. The two ends of the antenna coil, L_1, are fastened directly to these two terminals and the leads are bent to place L_1 directly opposite L_2 and close to the latter.

For best results, coil L_2 should be soldered directly to the two terminals of capacitor C_1, as shown in the photographs. This is more desirable than employing plug-in coils at ultra-high frequencies. The reader therefore should decide whether the receiver is to be used on 2 or 6 meters and should then solder the corresponding coil permanently into the circuit.

Complete wiring of the superregenerative receiver is illustrated by the circuit schematic Figure 73 and by the picture wiring diagram Figure 74.

Power Supply The superregenerative receiver requires two voltages; 6.3 volts a-c or d-c to heat the tube heaters and 250 to 300 volts d-c for the tube plates and screens. These may be obtained from a power supply of the same type and construction as the one described for the regenerative receiver and shown in Figures 66 to 70, or from a 6-volt storage battery and vibrator power pack.



SCHEMATIC OF THE SUPERREGENERATIVE RECEIVER

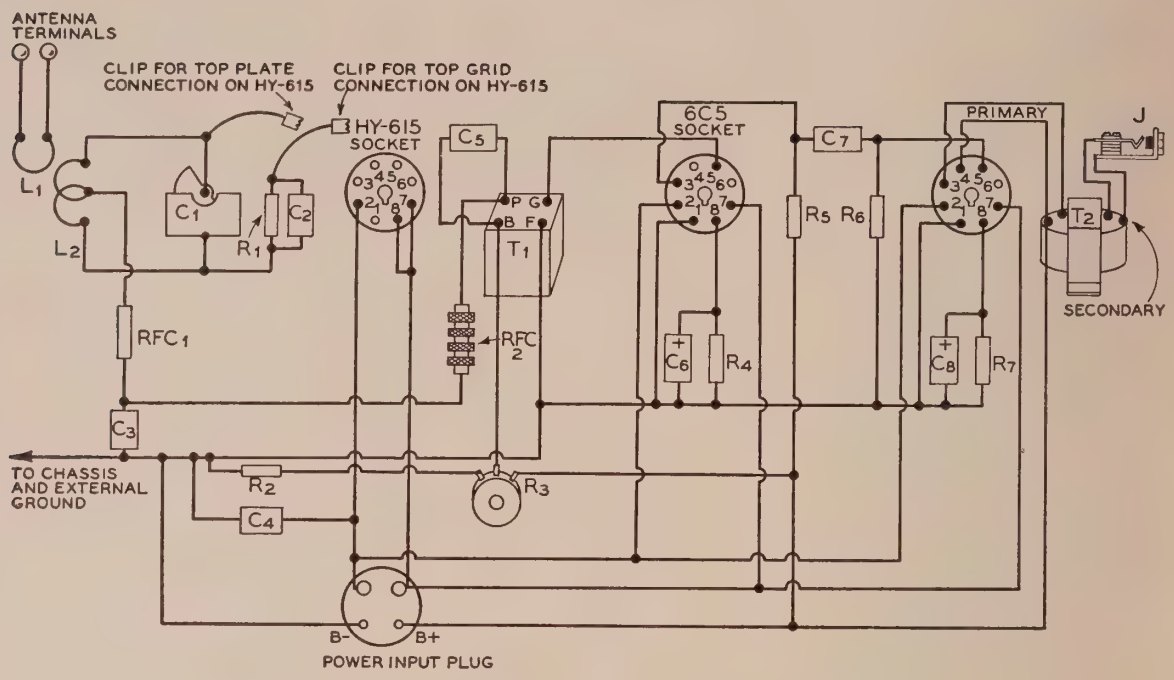
FIGURE 73

C1—15-mmfd. ultra-midget, ceramic-insulated variable capacitor
C2—100-mmfd. midget mica capacitor
C3—0.001-mfd. midget mica capacitor
C4—0.01-mfd. mica capacitor
C5—0.002-mfd. mica capacitor
C6—10-mfd. 50 d. c. w. v. tubular electrolytic capacitor
C7—0.05-mfd. 400-volt tubular capacitor
C8—25-mfd. 25 d. c. w. v. tubular electrolytic capacitor
J—Single-circuit, normally-open phone jack
L1—Single turn of No. 18 bare wire ½" in diameter, supported from antenna terminals and mounted close to grid end of coil L2.
L2—For 2 meters: 2 turns No. 14 tinned copper wire (bare) ½" in diameter, spaced ¼" apart. Tap placed at ½ turn from plate end. For 6 meters: 5 turns, ½" diameter, spaced ¼" apart. Tap at end of first turn from plate end.
R1—10,000-ohm ½-watt resistor
R2—100,000-ohm 1-watt resistor
R3—100,000-ohm potentiometer
R4—2000-ohm 1-watt resistor
R5—50,000-ohm 1-watt resistor
R6—500,000-ohm ½-watt resistor
R7—350-ohm 2-watt resistor
RFC1—Ohmite Type Z-1 u. h. f. radio-frequency choke
RFC2—2½-millihenry pi-wound r. f. choke
T1—2-to-1 ratio interstage audio transformer
T2—Universal output transformer (Select proper taps to match 6F6 tube to reader's loudspeaker).

Operation When the superregenerative receiver is in operation, a continuous hiss will be heard from the loudspeaker. This noise disappears completely when a strong signal is tuned in and is reduced considerably by weaker signals.

Perhaps the easiest way to place this receiver into operation will be to connect antenna and ground to the two antenna terminals and to tune in 2- or 6-meter signals. If the entire amateur band (as observed by logging stations across the main tuning dial) does not spread over a large enough part of the dial to afford sharp tuning and easy separation of stations, the turns of coil L_2 may be spread apart slightly or pushed together experimentally as circumstance is observed to require. The best position of regeneration control R_3 will be that which gives strong signals with best voice quality and lowest hiss.

The spacing (coupling) between the two coils (L_1 and L_2) must be adjusted by bending L_1 to or away from L_2 until a point is found where the



PICTURE DIAGRAM OF THE SUPERREGENERATIVE RECEIVER

FIGURE 74

antenna has the least effect upon the receiver. When coupling is too close, a dead spot (a virtual "hole" in the hiss) will be found at one or more points on the dial. Signals will disappear at this point; hence it is undesirable to have such dead spots within the tuning range. When the coupling is of the proper amount, no such dead spots will occur within that part of the tuning range covering the amateur band, although they might ap-

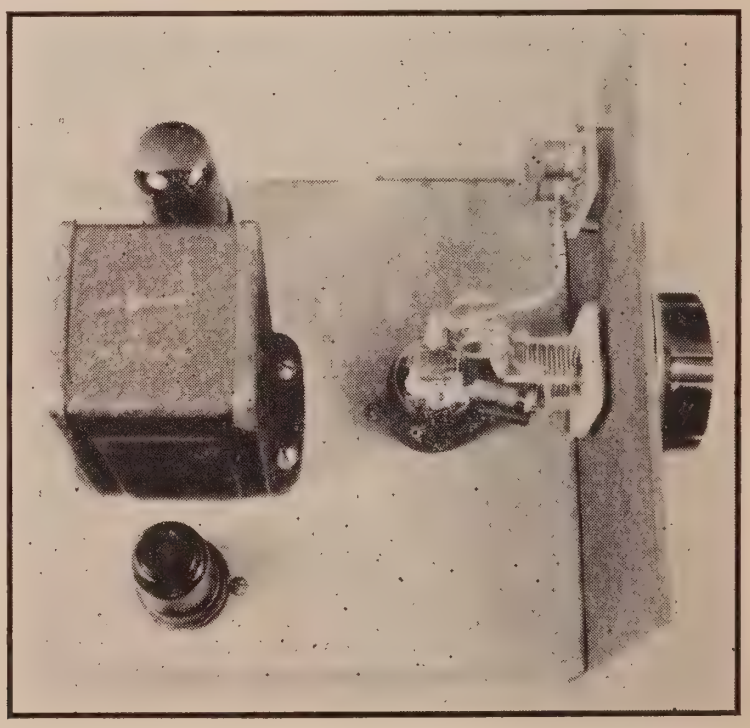


FIGURE 75

Top View of the Superregenerative Receiver.

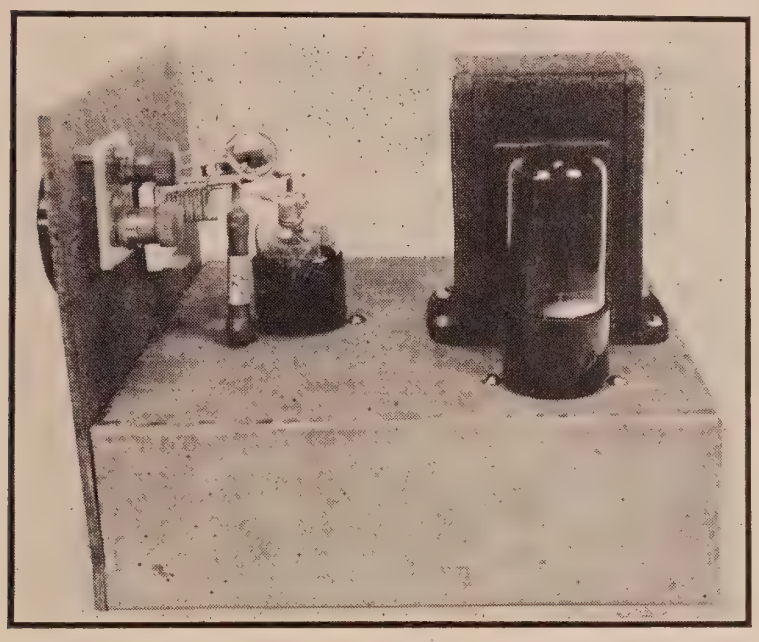


FIGURE 76
Side View of the Superregenerative Receiver.

pear outside of this range on either side of it.

If desired, headphones may be connected in series with the 6C5 plate in place of resistor R_5. In fact, if the builder is quite sure he will have no use for loudspeaker operation, he may so connect in a headphone jack and omit the 6F6 stage entirely.

If the builder has available a test oscillator or signal generator that furnishes either fundamental or harmonic signals on the 2- or 6- meter bands, he may calibrate the main tuning dial directly at a number of points and prepare a dial calibration chart. Otherwise, he must depend upon signals from the air, as already explained.

Although any type of antenna, with or without a ground, may be used with the superregenerative receiver, top performance usually will be obtained with a special ultra-high-frequency antenna. See the antenna chapter of this book for details of such an antenna.

Superheterodyne Receiver

The best all-around performance is obtained from a superheterodyne receiver. Technical operation of this type

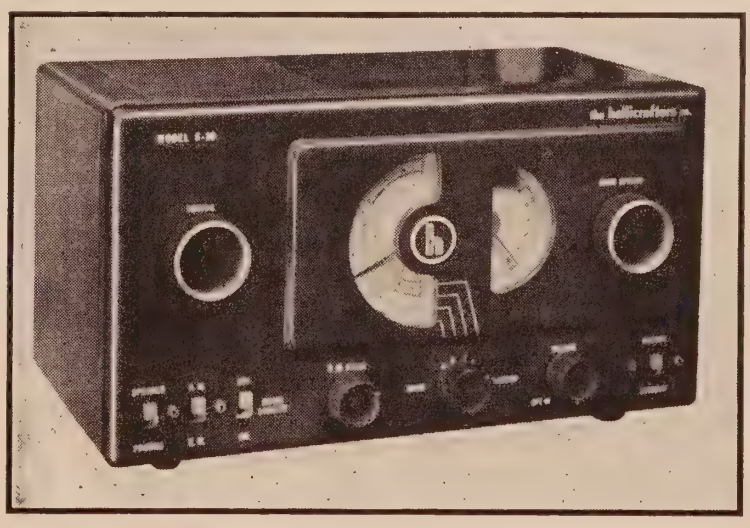


FIGURE 77
Low-Priced Communication Superheterodyne Receiver (Courtesy The Hallicrafters, Inc.)

of receiving set was explained in the chapter *How Radio Signals Are Sent and Received*. "Superhets" are very sensitive and selective and are especially desirable for radiophone reception. They are widely used in the amateur bands between 10 and 80 meters. However, the superhet is exceedingly complex, by comparison with the regenerative receiver, and we do not recommend that an amateur newcomer build one unless he is well experienced in radio receiver construction and alignment and unless he possesses the equipment required to do a first-class job of alignment. We accordingly do not give constructional details of a superheterodyne receiver here.

Even the man who is equipped to build a complex receiver will agree that it usually is cheaper in the long run and more satisfactory all around to buy a factory-built superhet for general purpose amateur station use.

Superheterodyne receivers designed expressly for high-frequency reception, including amateur band use, are known technically as *communication receivers*. Several well-known radio manufacturers produce such receivers in several price classes.

Figure 77 shows a typical manufactured amateur communication receiver in the low-priced category. This set comes complete with a self-contained a-c power supply but may be operated from external batteries for portable use or during power-line failures. A loudspeaker is contained within the unit.

CHAPTER SEVEN

Amateur Radio Transmitters

The newcomer's transmitter, like his receiver, need not be complicated. It is possible to carry on satisfactory long-distance communication, especially when using c-w telegraphy, with a relatively simple, low-powered transmitter. A well-built low-powered transmitter operated intelligently and coupled to a good antenna has been known to outstrip higher-powered rigs in the hands of less careful or less skillful operators.

In this chapter, we give the constructional details of several inexpensive transmitters which may be built with little or no difficulty. One of these transmitters with one of the receivers described in the preceding chapter will make an inexpensive newcomer's station.

The newcomer is warned ahead of time that the voltages employed with transmitters, even small rigs, are high enough to be dangerous. These voltages must be respected. If you *must* pry into the insides of your transmitter with the high voltage switched on, use an insulated-handle tool and hold it with one hand, *keeping your other hand in your pocket!* Amateurs have been electrocuted by their own apparatus. Therefore, take heed. Know the circuits of your equipment thoroughly —and keep all parts of your body clear of all high voltage points. It is a good rule always to be cautious when working on any circuit carrying more than 100 volts.

The newcomer is warned also not to test *any* transmitter connected to any

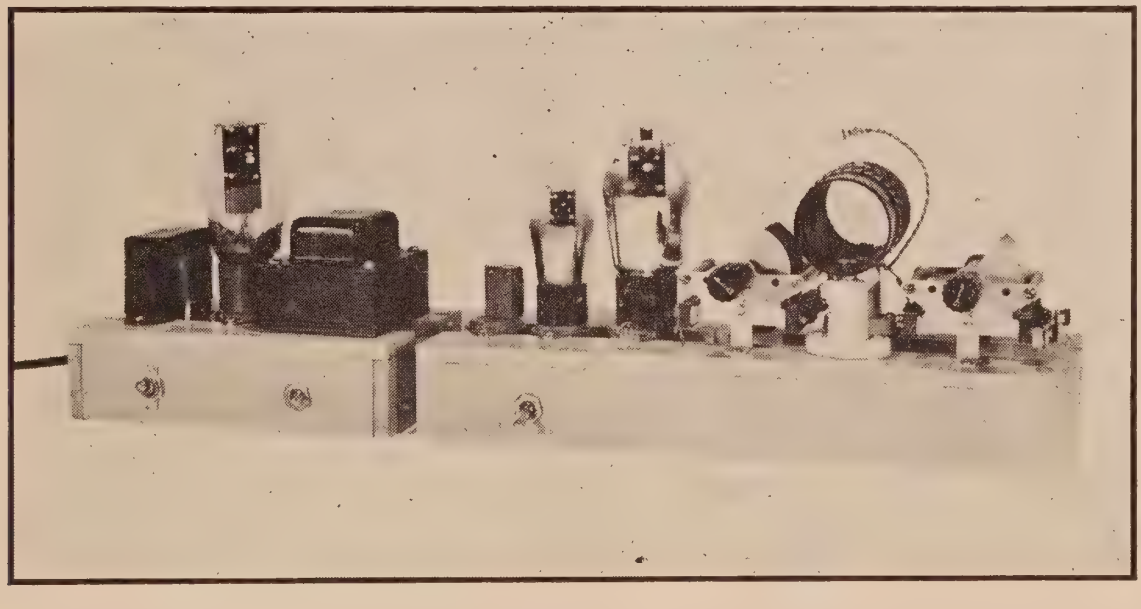


FIGURE 79

40-80 meter transmitter and power supply. No high voltage appears above the chassis.

form of antenna, outdoor or indoor, until he has obtained *both* his operator and station licenses.

Beginner's C. W. Transmitter

Figures 79 to 82 show the simplest efficient transmitter with which a newcomer can get on the air. This is a two-tube c-w telegraph transmitter of the crystal oscillator, power amplifier type, with a one-tube power supply. All of the components required in this set are inexpensive. While a keyed crystal oscillator working directly into the antenna could be used, the additional stability, power output and complete absence from keying chirps usually encountered when the crystal oscillator is keyed, makes the few extra parts well worth while.

A type 6J5 tube operating as a "Pierce" oscillator, without any tuned circuit, is fed into a 6L6 power amplifier. While glass tubes are shown, metal ones would be as satisfactory if pin Nr. 1 connected to the metal shell of the tube, is connected to the ground bus. A 5U4 full-wave rectifier tube is used in the power supply. The transmitter will deliver between 10 and 15 watts to the antenna on 80 meters and approximately 5 to 8 watts on 40 meters, the same crystal and coil being used for both bands.

When a Class A license is secured, the modulator and power supply described for the 10-meter set, may be used on this transmitter for 80-meter radiophone operation. Neither a Class B nor a Class C operator's license carry this privilege it must be remembered however.

Constructional Hints Both the power supply and transmitter are mounted on simple wooden chassis, made of "battens" having dimensions of 1¾ by ⅜ inches. More than enough to build these two chassis can be obtained from a lumber mill for around twenty cents. The pieces are nailed together with one inch long, thin nails called "brads."

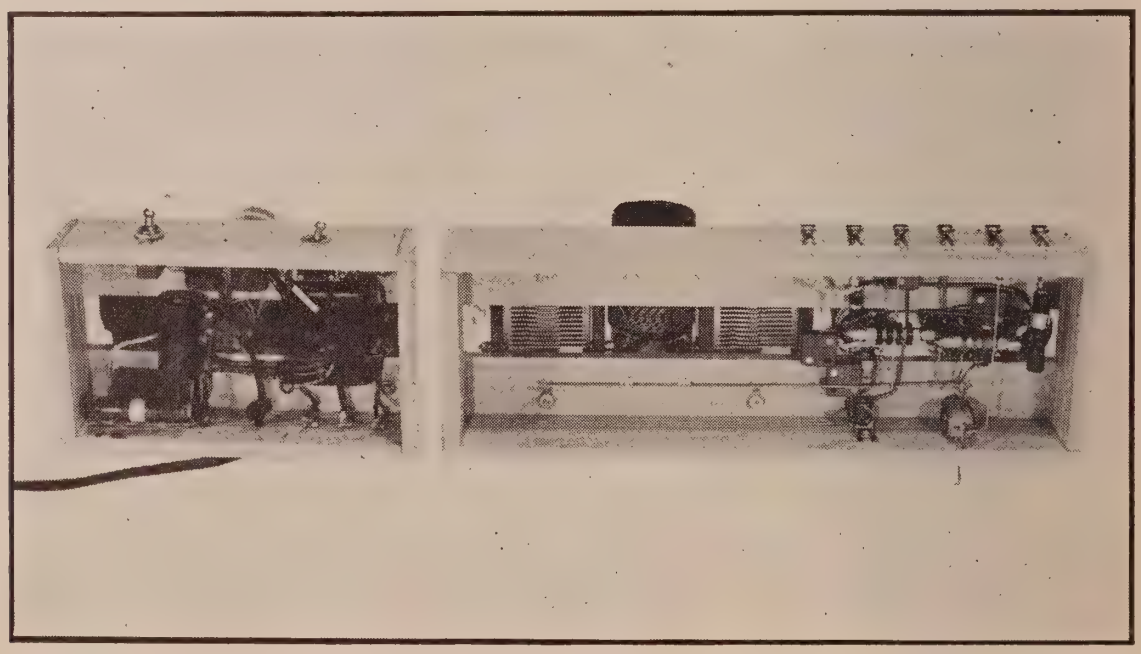
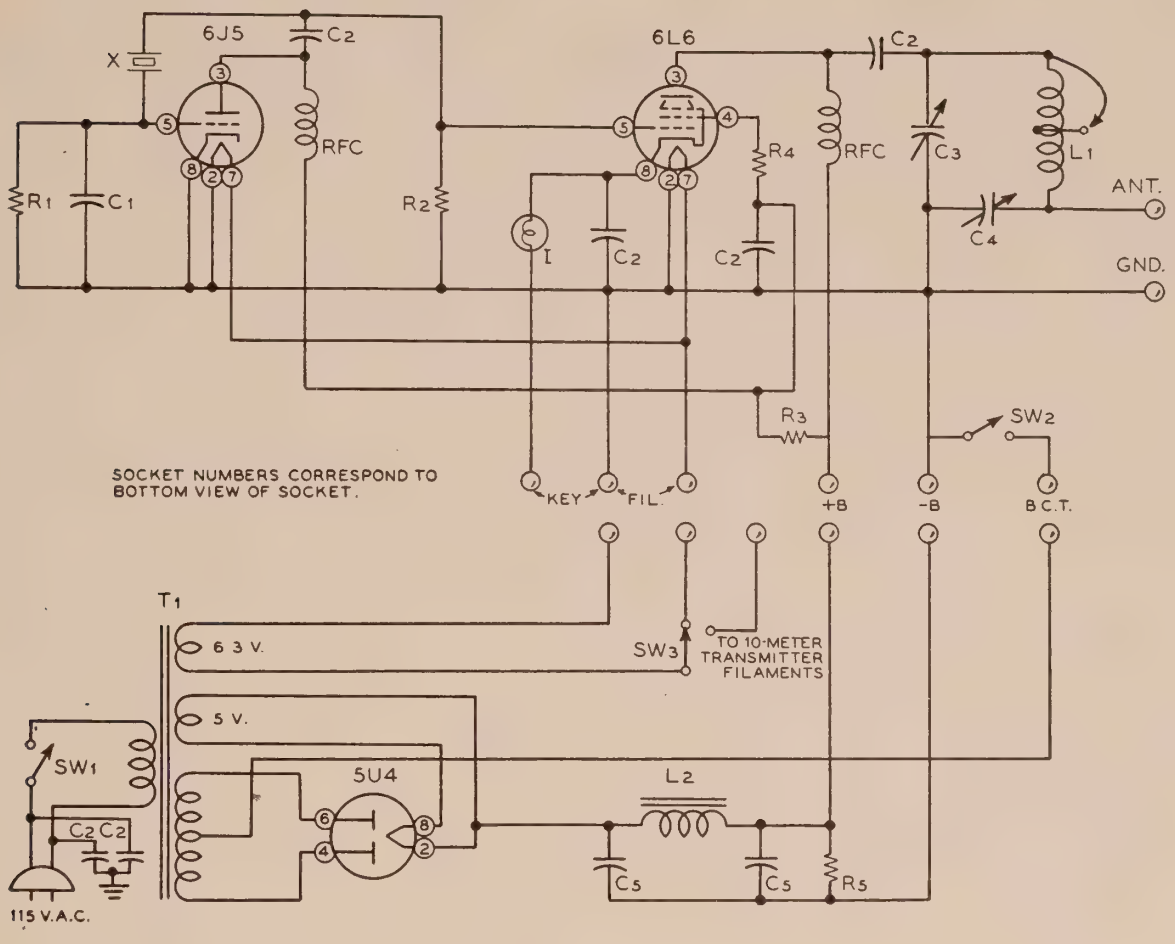


FIGURE 80

Bottom view of 40-80 meter transmitter. Nameplate is hand printed on drawing paper and cemented under clips. Note busbar to which all grounds are made.



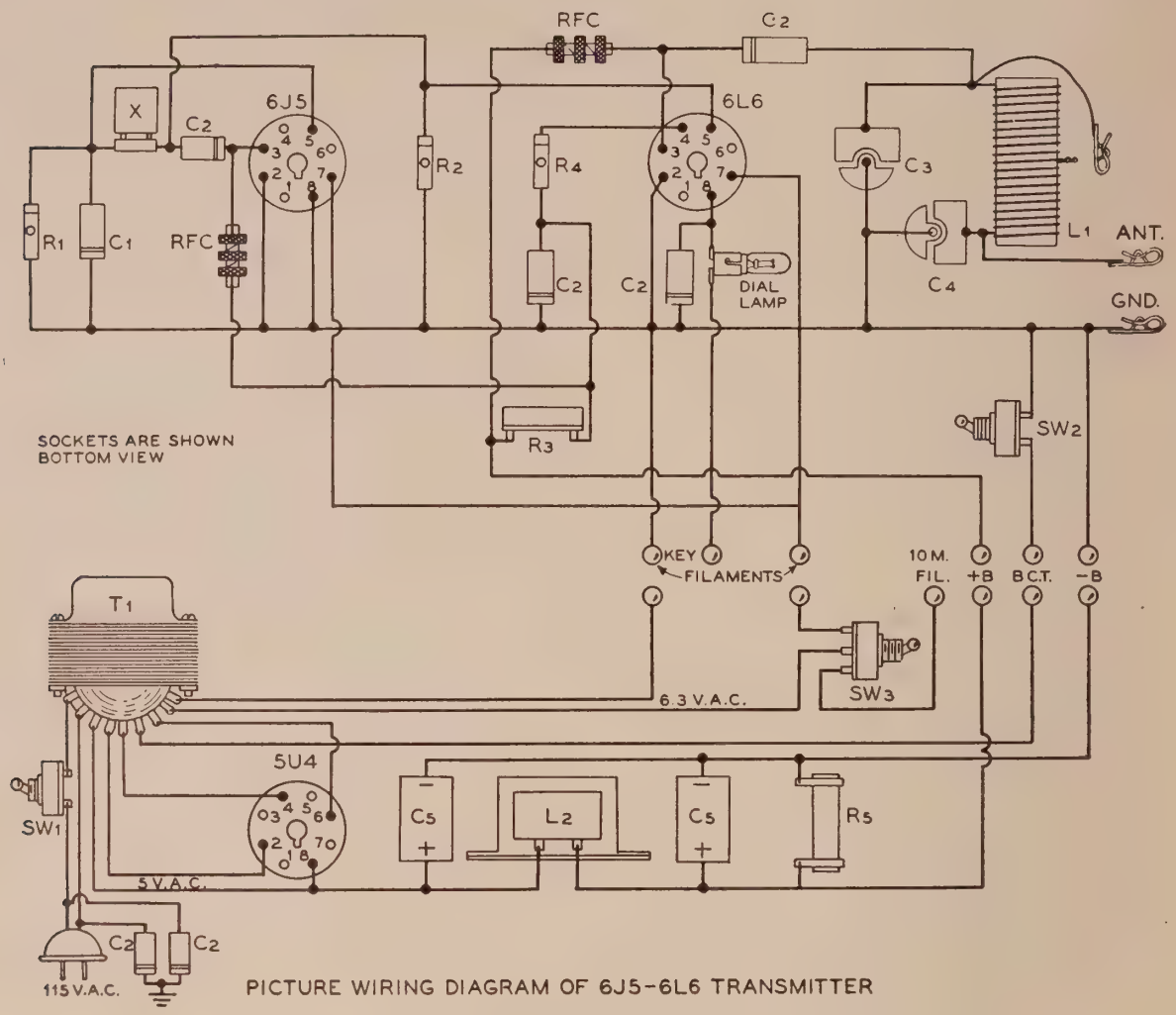
SCHEMATIC OF THE 6J5-6L6 TRANSMITTER

FIGURE 81

R1—22,000 ohm ½ watt resistor
R2—47,000 ohm ½ watt resistor
R3—25,000 ohm 10 watt resistor
R4—47 ohm 2 watt resistor
R5—50,000 ohm, 20 watt resistor
C1—50 mmfd. midget mica capacitor
C2—.002 mica capacitor (6 needed)
C3 and C4—250 mmfd. variable capacitor
C5—8 mfd., 450 volt tubular electrolytic capacitor (2 needed)
I—60 ma dial light bulb type 40A or 49A (Sylvania type S47 or S49) and socket
RFC—Radio frequency choke, 2.5 mh (National R-100 or similar) (2 needed)
SW1 and SW2—Single pole, single throw toggle switches
SW3—Single pole, double throw toggle switch
T1—Power transformer. High voltage secondary 400 volts each side of center tap, 100 ma. Two filament windings; 5 volt 2 amp and 6.3 volt 3½ amp.
L1—20 turns of hookup wire close wound on 2 inch tube, tapped at 10th turn
L2—6 to 10 henry, 100 ma filter choke
X—80 meter crystal..

Note: The following additional material is required:

9 feet of 1¾ x ⅜ inch battens
1x19 wire brads
4 octal tube sockets, chassis type
15 Fahnestock clips
1 6J5 tube
1 6L6 tube
1 5U4 tube
1 110v plug
2 inch bakelite tube, 3½ inches long
2 dial knobs
110v duplex wire, hookup wire, busbar, nuts, bolts, screws and soldering lugs as needed
2 porcelain standoff insulators



PICTURE WIRING DIAGRAM OF 6J5-6L6 TRANSMITTER

FIGURE 82

Several coats of gray paint improve the appearance. In the units illustrated in Figures 79 and 80, the power supply chassis is 8 inches long by 4¾ inches wide by 2⅛ inches high. The transmitter chassis is 14 inches long, the other dimensions being the same as the power supply. These dimensions can be varied to suit the size of the components you use.

All wiring must be done as neatly as possible, using insulated hookup wire and soldering all connections. The common ground strip or "bus" is of heavier tinned copper wire and makes a convenient terminal to run all grounds to. Unused socket terminals can be used to help mount the resistors, capacitors and chokes to keep them rigid. Do not solder one terminal of those components to a part and leave the opposite end dangling from a wire going to the next part.

As a safety precaution, the circuit is designed so that no parts above the chassis have high voltage on them. Connections between the transmitter and power supply are made by means of Fahnestock clips bolted to the rear of the chassis. 6/32 bolts and nuts may be used in their place in the form of binding posts or a plug and socket and multi-wire cable. The clips are the easiest form of construction however. Parts appearing above the top of the two chassis are bolted or

screwed to the top battens, which are just far enough apart to take the tube sockets, 1¼ inches in this case.

As a convenience in turning the set on and off, a switch is mounted on the front of the power supply. A single-pole double-throw toggle switch is also mounted to transfer the filament voltage to the 10-meter transmitter described later. A switch on the front of the transmitter chassis turns off the crystal oscillator when receiving. Sufficient insulation is provided by the wood chassis construction to permit of mounting all parts directly on it, with the exception of the coil which is mounted on standoff insulators. A dial light of the type used with 2-volt battery sets and drawing 60 milliamperes, is incorporated as a tuning indicator, the socket being mounted underneath the chassis with the bulb projecting through the top. It may be seen in front of the 6L6 tube in Figure 79. A regular 0-150 milliammeter is preferable for more accurate adjustments. Antenna and ground connections are made to two Fahnestock clips attached to the rotor and stator respectively, of the right hand variable condenser.

No additional antenna tuning coupler is necessary using this "pi network" tuning system, however, a good ground should be connected to the B-minus lead of the transmitter. On 80 meters, both the crystal oscillator and power amplifier operate on that frequency. On 40 meters, the crystal continues to operate on 80 but half the turns in the coil are shorted out by the flexible shorting wire and clip, seen extending over the coil in Figure 79, permitting the power amplifier to double to the second harmonic or twice the frequency of the crystal. To permit operation within the limits of the 40-meter band however, the crystal frequency must be between 3500 and 3650 kc.

Do not under any circumstances eliminate the resistor in the power supply. This is a safety (bleeder) resistor which drains the dangerous electric charge from the filter condensers, protecting the operator from shock.

The antenna may be one of the types described in the Antenna chapter of this book.

Adjustment and Operation Connect the terminals on the rear of the transmitter marked "key" to a telegraph key and the other terminals to their corresponding ones on the power supply. With all tubes and the crystal in their respective sockets, turn on the power supply. If the transmitting tubes do not light, throw the filament transfer switch to the other position. Allow about a minute for the tubes to warm up. Throw the crystal-oscillator switch on and hold the key down. Watching the indicator light, rotate C_3 very slowly until the light dims and then comes back as the capacitor is rotated further. The center of this dip is the correct adjustment of C_3. If no dip is found, rotate capacitor C_4 one way or the other and try again until this point is found. A loop of wire connected to a flashlight or dial-light bulb (See Fig. 103) held near the coil, will light up brightly as will a small neon bulb touching the antenna terminal, indicating the presence of r. f.

Connect the antenna to the set and retune C_3 for either minimum dip in the bulb or maximum brightness of the loop. If the antenna is a half wavelength long, tune both capacitors for maximum brilliance in the neon bulb touching the antenna terminal. If the antenna is a quarter-wavelength long, use the loop as an indicator that the antenna is drawing power from the amplifier. As power is drawn, the loop will dim after which capacitor C_3 must

be changed to again bring it up to maximum brilliance. Capacitor C_4 in effect adjusts the loading of the antenna, while C_3 tunes the transmitter. The use of a milliammeter in place of the 60-ma. dial light greatly facilitates this tuning process since it permits a more accurate indication of how the antenna is drawing power from the amplifier. As the antenna loads the amplifier, the current reading at minimum dip will go up, while the dip itself will be found to be less and less pronounced. With 350 volts from the power supply, the amplifier properly loaded will draw around 60 to 70 milliamperes. Plate voltage of the oscillator and screen voltage on the 6L6 will be 130 volts under these conditions. Always readjust C_3 for either minimum dip or maximum brilliance in the loop whenever any other adjustments are made.

One major advantage of the "pi" network is that the amplifier may be loaded and energy fed into a wire of almost any length, although of course, an antenna cut for the frequencies used is far more efficient.

For 40-meter operation, follow exactly the same tuning procedure except that half of the coil should be shorted out by the flexible lead being clipped on the coil tap. Do not look for a dip in the indicator light but tune instead for maximum brilliance in the loop.

Listen to your signals with your own receiver, with the volume reduced to the lowest audible level and with no antenna on it. The simple regenerative receiver described in the preceding chapter may be used as a monitor in this manner. Your keyed signals should be clean-cut whistles without chirps or roughness. The note of the crystal oscillator will be heard running continuously but since it does not go into the antenna, it does not matter unless you are receiving on the same frequency as you are sending on, in which case it is cut off with the switch on the front of the transmitter, while receiving.

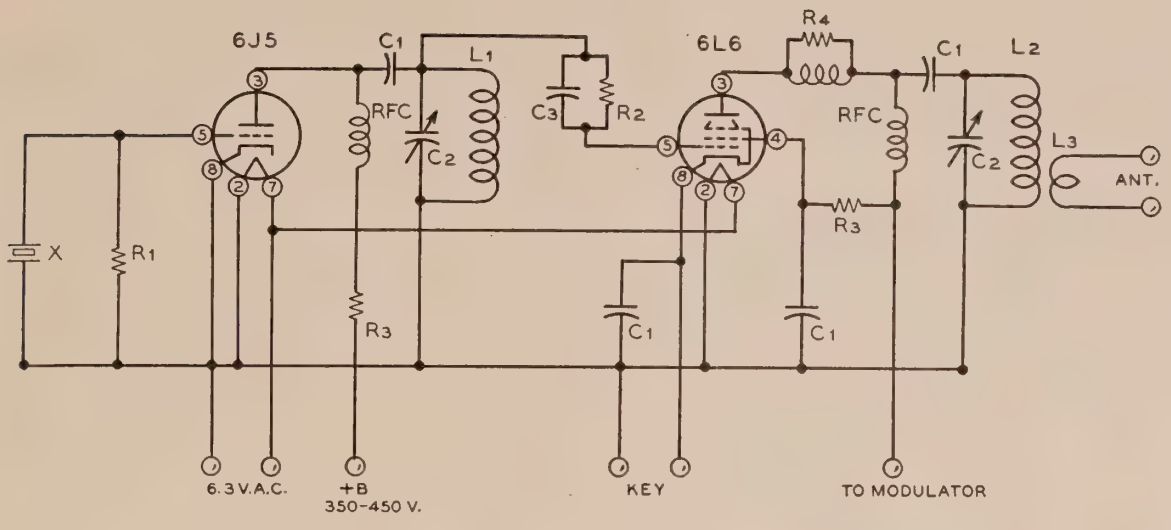
Beginner's 10-Meter Transmitter

Figures 83 and 84 show a simple 10-meter transmitter. Figure 85 pictures the bottom of the chassis while the top is shown in Figures 89 and 90.

Arrangement . The same 6J5 and 6L6 tubes used in the previously described 40-80 meter transmitter may also be used in this one, together with the same power supply shown in Figures 79 to 82, making the additional cost of getting on 10-meter c. w. a minimum if the previous transmitter has already been built.

A 6J5 using a 20-meter crystal is incorporated in a tuned oscillator circuit feeding a 6L6 which is tuned to amplify only the second harmonic of the oscillator or 10 meters. Provision is made for coupling to a concentric or twin-lead line to feed the antenna.

For c. w. operation only, a crystal operating between 14,000 and 14,850 kc may be used. For phone operation in the 10-meter phone band however, the crystal must lie in the range between 14,250 and 14,850 kc to permit doubling to the 28.5-29-7 mc phone band. Operation in this phone band does not require a Class A license, making it particularly interesting to a beginner, additionally so because under good conditions, distances of thousands of miles may be spanned with the simple equipment herein described. "Ten" in fact, has the interesting characteristic of being excellent for local work and when the band is open, of jumping a thousand or more miles with ease.



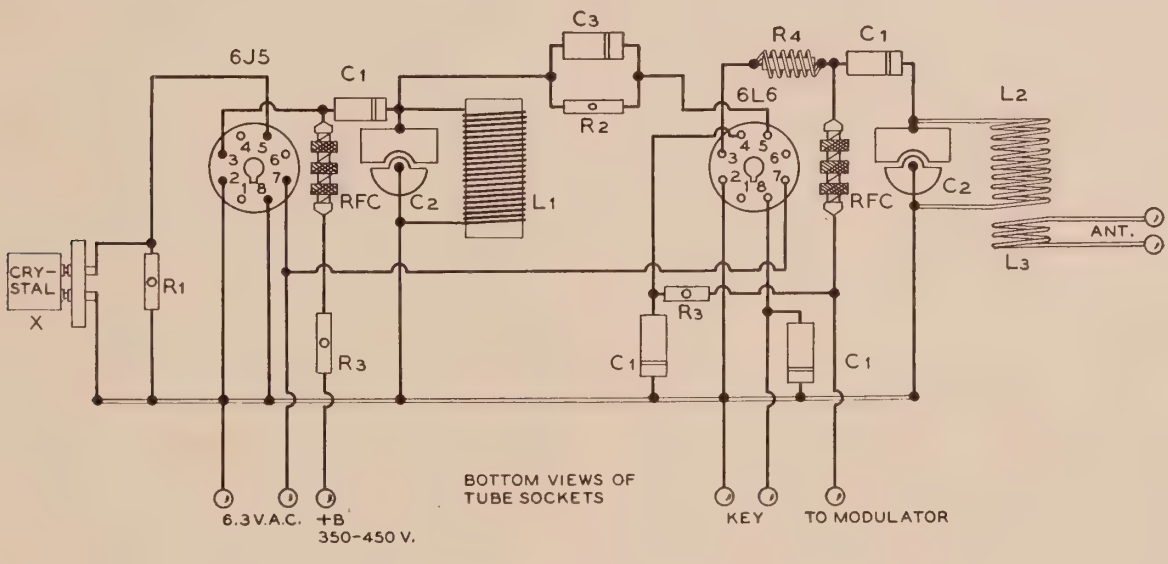
SCHEMATIC OF THE 10 METER TRANSMITTER

FIGURE 83

R1—22,000 ohm, ½ watt resistor
R2—47,000 ohm, ½ watt resistor
R3—25,000 ohm, 5 or 10 watt resistor (2 needed)
R4—47,000 ohm, 1 watt resistor
R5—47 ohm, 1 watt resistor
C1—.002 mfd. mica capacitor (4 needed)
C2—50 mmfd. variable capacitor (2 needed)
C3—.001 mfd. mica capacitor
L1—10 turns Nr. 12 enameled wire, 1 inch diameter close wound
L2—6 turns Nr. 12 enameled wire, 1 inch diameter spaced ⅛ inch between turns
L3—4 turns Nr. 12 enameled wire, 1 inch diameter spaced ⅛ inch between turns
X—20 meter crystal
RFC—2.5 mh R.F. choke (2 needed)

Note: The following additional material is required:

3 feet of 1¾ x ⅜ inch battens
1 x 19 wire brads
3 octal tube sockets, chassis type
6 Fahnestock clips
2 midget standoff insulators
1 6J5 tube
1 6L6 tube
2 dial knobs



PICTURE WIRING DIAGRAM OF THE 10 METER TRANSMITTER

FIGURE 84

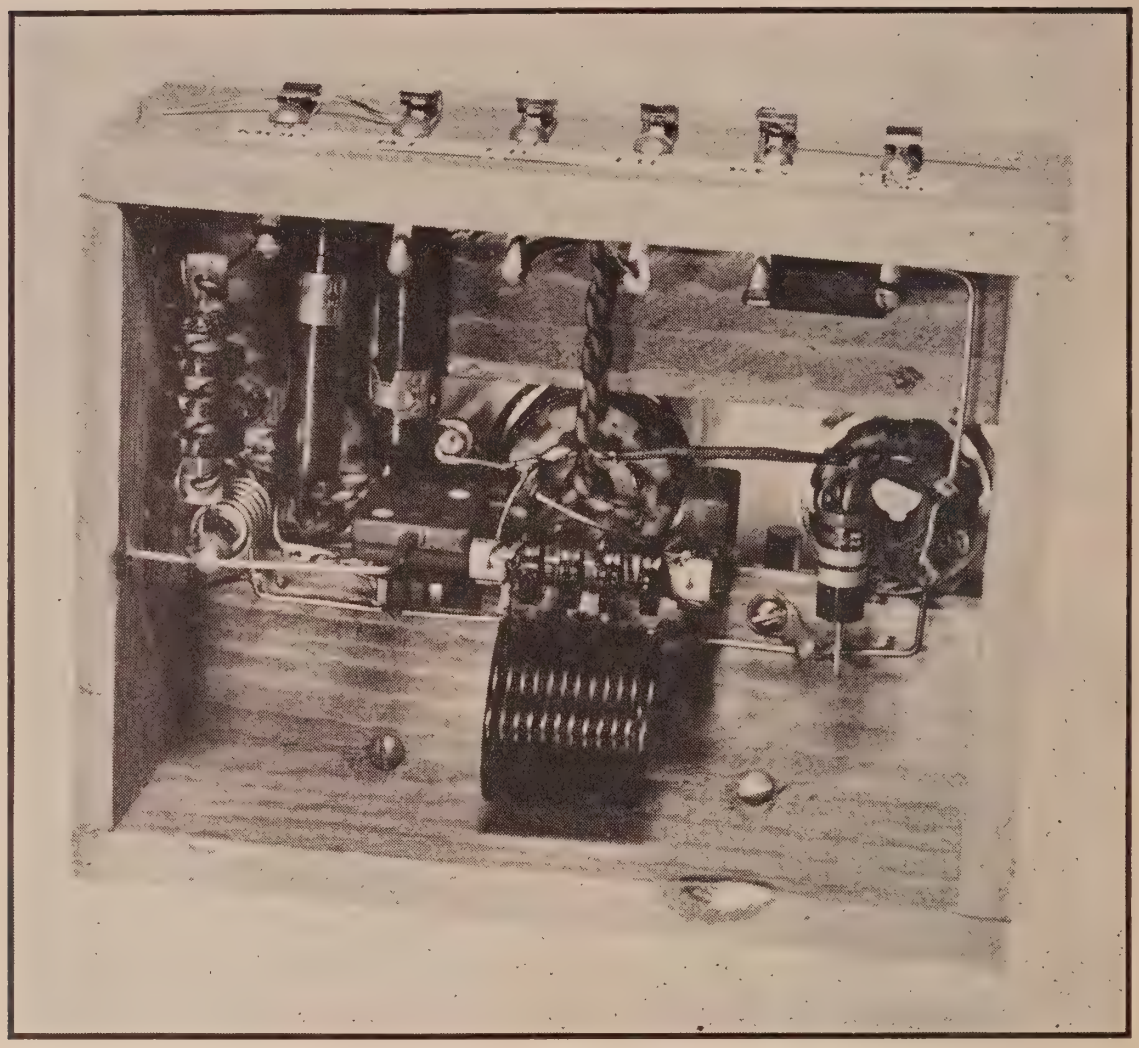


FIGURE 85
Under chassis view of 10 meter transmitter showing location of parts and 20 meter coil.

Construction Construction is simple and follows the general layout of the 40-80 transmitter. Since smaller variable condensers and coils can be used, the chassis dimensions can be reduced to a length of 6 inches, other dimensions remaining the same.

The oscillator tuning capacitor is mounted on the left front part of the chassis and the final stage tuning capacitor on the right. Both coils are wound of enameled wire on a 1-inch form, a metal receiving tube making a good winding form. The oscillator coil is wound without spacing and is mounted underneath the chassis to keep it isolated from the power amplifier coil. After the amplifier and antenna coils are wound, the shaft of a medium sized screwdriver is run around the turns, which spreads them the ⅛ inch or so required. The antenna coil is soldered to two solder lugs mounted on midget standoff insulators. These are located on the right hand front end of the chassis, close to the ground end of the amplifier coil. Note that these coils must be wound in the same direction.

The coil which is shown in Figures 83 and 84 shunting resistor R_5, is a parasitic suppressor and may be easily made by winding five or six turns of

heavy wire around the resistor R_5 itself, soldering the ends to the terminals of that resistor.

To protect the operator, this set has been designed so that no high voltage appears above the chassis. The tuning capacitors and amplifier coil are all at ground potential.

Adjustment and Operation For c. w. operation, connect the terminals marked "MOD" and "B+" together. Connect "BCT" and "B—" terminals on the power supply together. Connect all other terminals to their respective ones on the power supply.

A dial light bulb connected to a two-turn loop of the same diameter as the coils, is used for tuning. With the crystal plugged in, insert the 6J5 tube in its socket and apply filament and plate voltages. When the tube has warmed up, hold the dial light bulb close to the coil and rotate the oscillator variable capacitor until the bulb glows, indicating oscillation.

While dependent upon the characteristics of the crystal, it is more than likely possible that if this capacitor is fully meshed and then slowly opened, the crystal will oscillate stronger and stronger until it reaches a peak and sharply breaks out of oscillation. It should also be noted that to again bring the crystal into oscillation once this peak is passed, the condenser must again be fully meshed and brought slowly back out. The correct setting of the oscillator condenser is such that it is as close to the point of maximum oscillation as possible, when the transmitter is feeding the antenna and being keyed.

Insert the 6L6 tube in it's socket and with the crystal oscillator running, short the terminals marked "KEY" and rotate the amplifier variable condenser. A point will be found where the dial light bulb and loop, placed near the 6L6 coil, will glow brightest. When this is found, reset the oscillator condenser for maximum brilliance in the bulb, consistent with stability of the crystal. Couple the concentric or twin-lead antenna feeders to the terminals of the antenna coil and adjust this coil as close to the amplifier as possible, consisten with clean sharp keying as evidenced by listening on the receiver. Antennas suitable for this transmitter are described in Chapter 8.

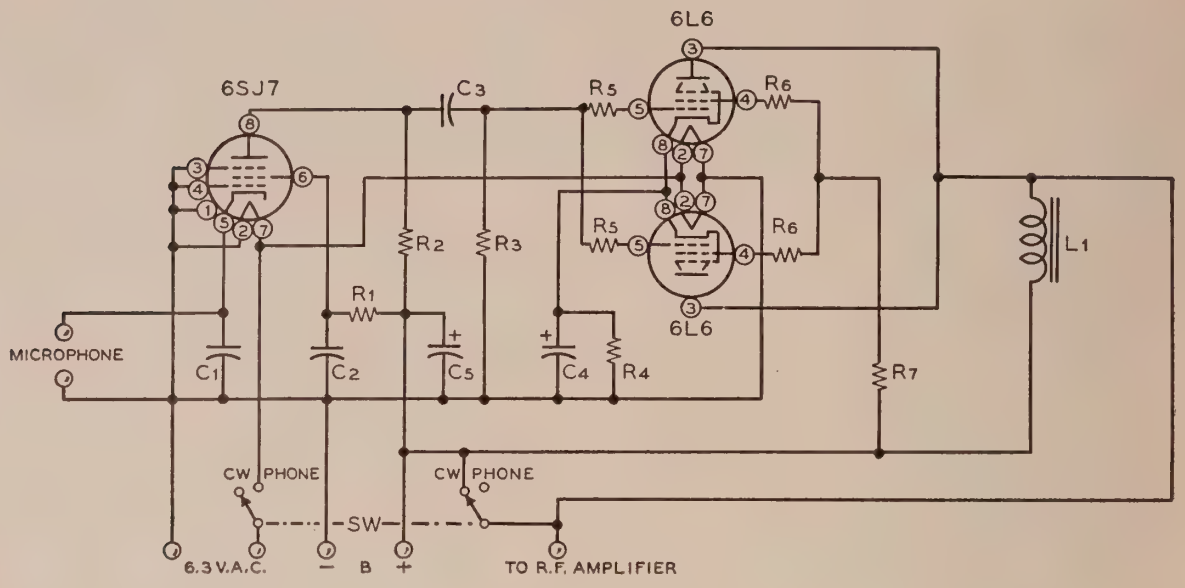
If metal tubes are used in place of glass, connect pin Nr. 1 of the tube sockets to the common ground bus. It is always a good idea to do this anyway, so that metal or glass tubes may be interchanged.

Modulator

A modulator suitable for either the 10-meter transmitter or the 40-80 meter one, is illustrated in Figures 86 to 89. It consists of a 6SJ7 speech amplifier driving two 6L6 tubes in parallel. Heising modulation is used, choke L_1 being the modulation inductance. A double-pole, double-throw switch transfers from phone to c. w. by opening the filament circuit of the modulator tubes and shorting the modulation choke in the c-w position.

The speech amplifier is designed to use a single button microphone similar to an ordinary telephone microphone. No microphone transformer or battery is necessary and by talking close to the mike, sufficient volume is delivered by the 6SJ7 to drive the 6L6 tubes for 100% modulation in either transmitter.

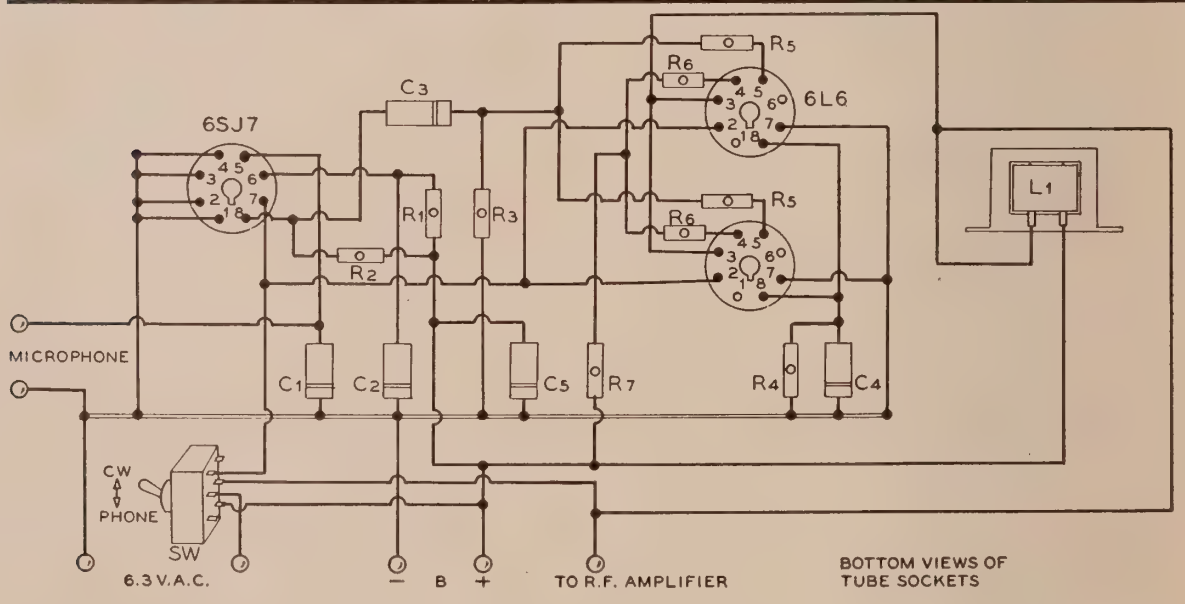
Construction follows the other units described, the length of the chassis being dependent upon the size of the components. In the model illustrated, this is 11 inches. The same power supply as used for the 10 or 40-80



SCHEMATIC OF MODULATOR

FIGURE 86

R1—330,000 ohm 2 watt resistor
R2—100,000 ohm 2 watt resistor
R3—220,000 ohm 1 watt resistor
R4—330 ohm 2 watt resistor
R5—100,000 ohm ½ watt resistor (2 needed)
R6—47 ohm 1 watt resistor (2 needed)
R7—25,000 ohm 10 watt resistor
C1—.002 mfd. mica capacitor
C2—.25 mfd., 250 volt tubular capacitor
C3—.01 mfd. tubular capacitor
C4—25 to 40 mfd., 150 volt electrolytic tubular capacitor
C5—8 mfd., 500 volt tubular electrolytic capacitor
L1—200 ma, 6 to 10 henry choke coil, low resistance
Note: The following additional parts are required:
1 6SJ7 tube
2 6L6 tubes
3 octal sockets, chassis type
5 feet of 1¾ x ⅜ inch battens
1 x 19 wire brads
1 double pole, double throw toggle or rotary switch
1 dial knob if rotary switch is used
7 Fahnestock clips



PICTURE WIRING DIAGRAM OF MODULATOR

FIGURE 87

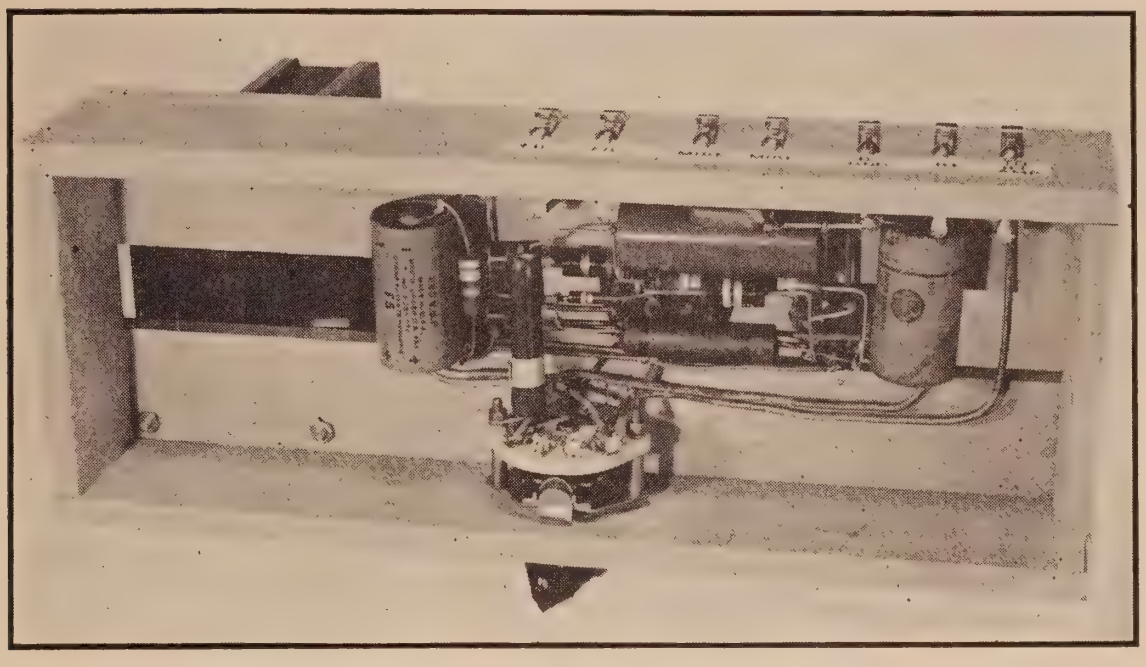


FIGURE 88
Wiring of modulator. A ceramic insulated rotary switch is used to change from CW to Phone.

meter transmitter may also be used for this modulator when working with either transmitter. Connections are made to the respective terminals on the 10-meter transmitter.

If the 80-meter transmitter is used

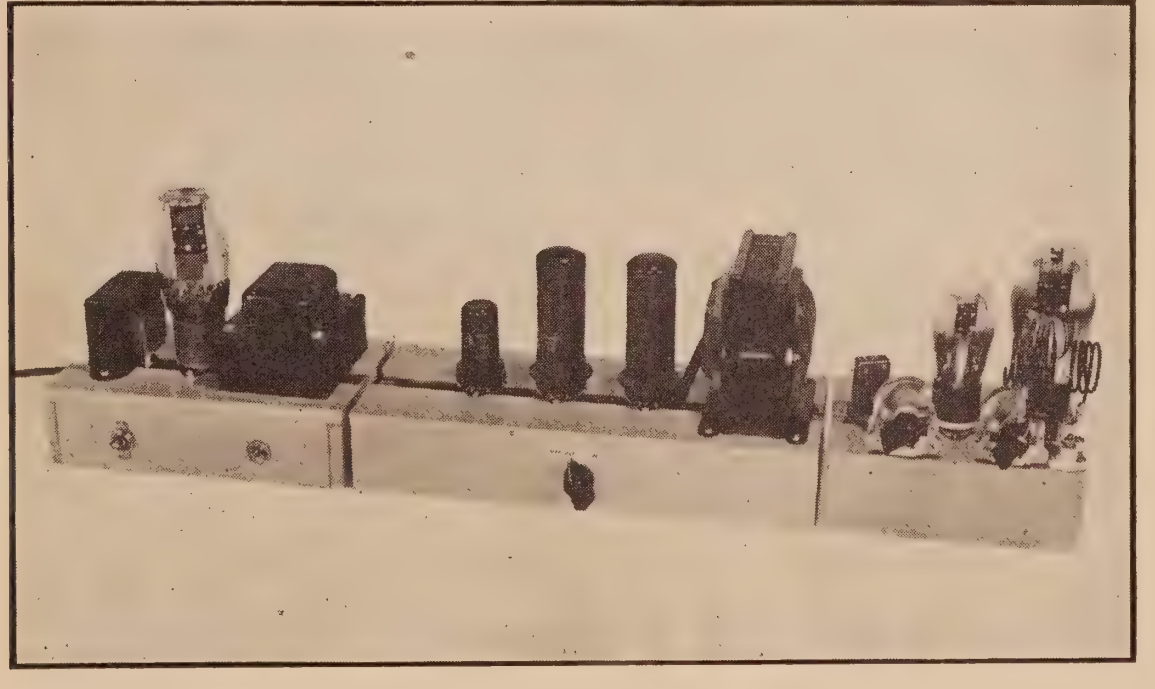


FIGURE 89
10 meter CW-Phone transmitter. The power amplifier coil is mounted directly on its tuning capacitor.

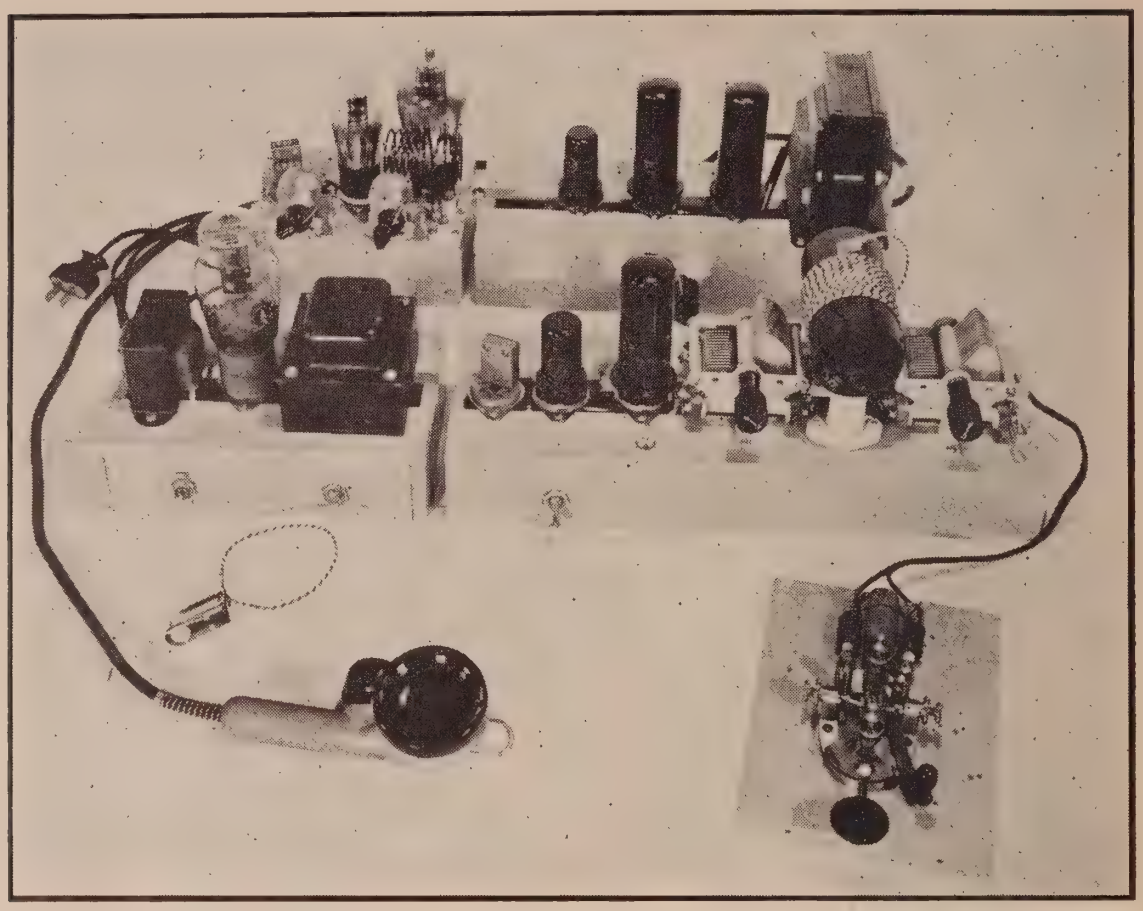


FIGURE 90

Complete transmitting equipment for 40 meter CW and 80 and 10 meter phone. Connection between these units is shown in Fig. 92.

on phone with a Class A license however, it will be necessary to bring the B+ of the 6L6 power amplifier in that transmitter, out to a separate terminal which will go to the "TO RF AMP" terminal of the modulator, to prevent modulation of the crystal oscillator.

Do not operate this modulator without a load on it's output, either in the form of a transmitter or a 10,000 ohm, 25 watt resistor, connected between the "TO RF AMP" and B— terminals, or damage may be done to the modulation choke.

Complete Station Figure 90 illustrates the two transmitters, modulator and power supply ready for operation, with key and microphone. With the addition of the regenerative receiver described in Chapter 6, together with either an all-wave antenna as described under "Simple Doublet Antenna" in Chapter 8, or separate antennas, you will have a complete 80-meter phone or c. w.; a 40-meter c. w. and a 10-meter phone or c. w. station at minimum expense.

Either the 10-meter or the 40-80 meter transmitter is turned on by the filament changing switch on the front of the power supply. The plate voltage on both transmitters may be turned off by the switch on the front of the 40-80 meter transmitter which opens the common B—. Figure 92 shows the connection of all units together. Changeover from c. w. to phone is ac-

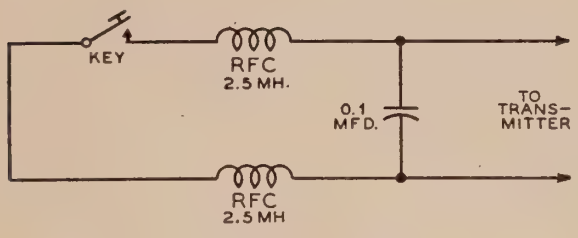


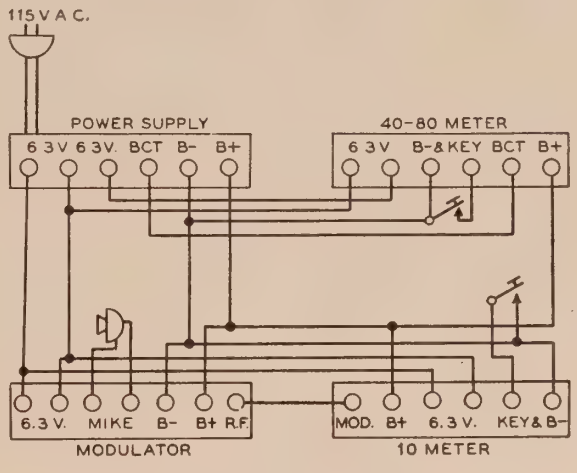
FIGURE 91

complished by the switch on the front of the modulator.

A key click filter is shown in Figure 91. This is mounted close to the key and greatly aids in minimizing thumps which might interfere with nearby receivers.

While the power supply described is satisfactory for normal operation of the apparatus illustrated, if more power is desired, the power transformer can be replaced by one having a higher voltage output, say 550 volts each side of center-tap and with a current rating of around 200 milliamperes. In this case, the two filter capacitors must be of a higher voltage rating than those shown, either 600-or 1000-volt ones. If capacitors of this higher rating cannot be afforded (many will be available at reasonable prices from war surplus stocks for some time to come), each capacitor can be replaced by two 16-mfd., 450-volt electrolytic capacitors connected in series, which will give a total capacitance of 8-mfd. and a voltage breakdown of approximately 900 volts for each pair. The 5U4 tube should also be replaced with a mercury vapor type 83 tube, in which case the rectifier tube socket must be changed from an octal to a four-pin type.

If untuned antenna feeders (coaxial or twin-lead lines) are used with the 40-80 meter transmitter, capacitor C_4 is left fully meshed and several turns of hookup wire placed near the ground end of the tuning coil. (See Figure 100). With both transmitters, when using radio-telephony, this coupling is adjusted experimentally until the dial light and loop, held near the amplifier coil, brightens up as the microphone is spoken or whistled into. Coupling is adjusted in the 10-meter set by bending the antenna coil toward or away from the amplifier coil. In the 40-80 meter set, it is accomplished by capacitor C_4 or by the nearness of the antenna coupling turns to the ground end of the coil in case of untuned feeders.



CONNECTIONS OF POWER SUPPLY, MODULATOR, 10 METER, AND 40-80 METER TRANSMITTER.

FIGURE 92

The simple listening monitor shown in Figure 99 and Figure 51 of Chapter 5, can be used to check the quality of voice transmissions.

To reiterate three words of caution:

1. Use great care that you do not come in contact with the high voltage.

2. Do not place these transmitters on the air until you have both an operator and station license.

3. Do not use 80-meter phone without a Class A license.

40-Watt Transmitter

The newcomer who has had previous experience in wiring, testing, and operating radio equipment and who has built simpler transmitters will find the

FIGURE 93
Top View of 40 watt Transmitter.

40-watt 7C5-807 transmitter, shown in Figures 93 to 98, most satisfactory. This transmitter gives a good account of itself both on c. w. and phone and can be used also as an unmodulated exciter in a more powerful transmitter. It covers all amateur bands from 10 to 80 meters.

Arrangement This transmitter consists of a 7C5 crystal oscillator, which may be operated at the crystal frequency or at 2 or 4 times that frequency, and an 807 amplifier which may be operated either as a "straight through" amplifier or as a frequency doubler. Any crystal from 10 to 80 meters may be employed in the oscilla-

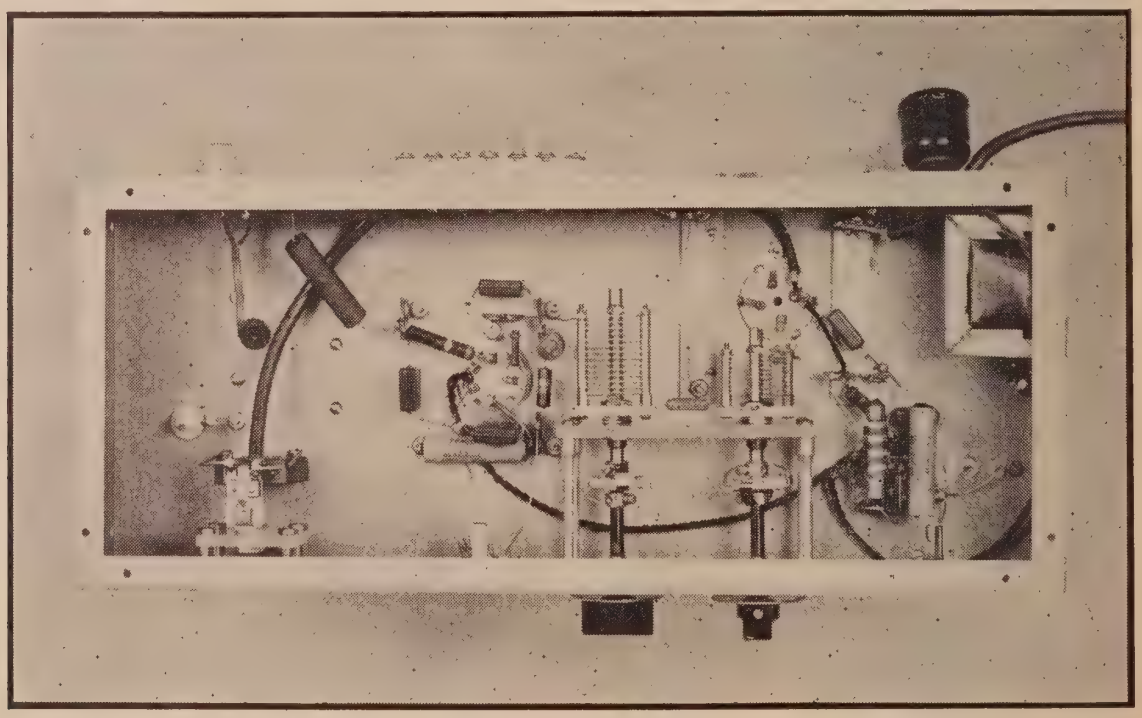
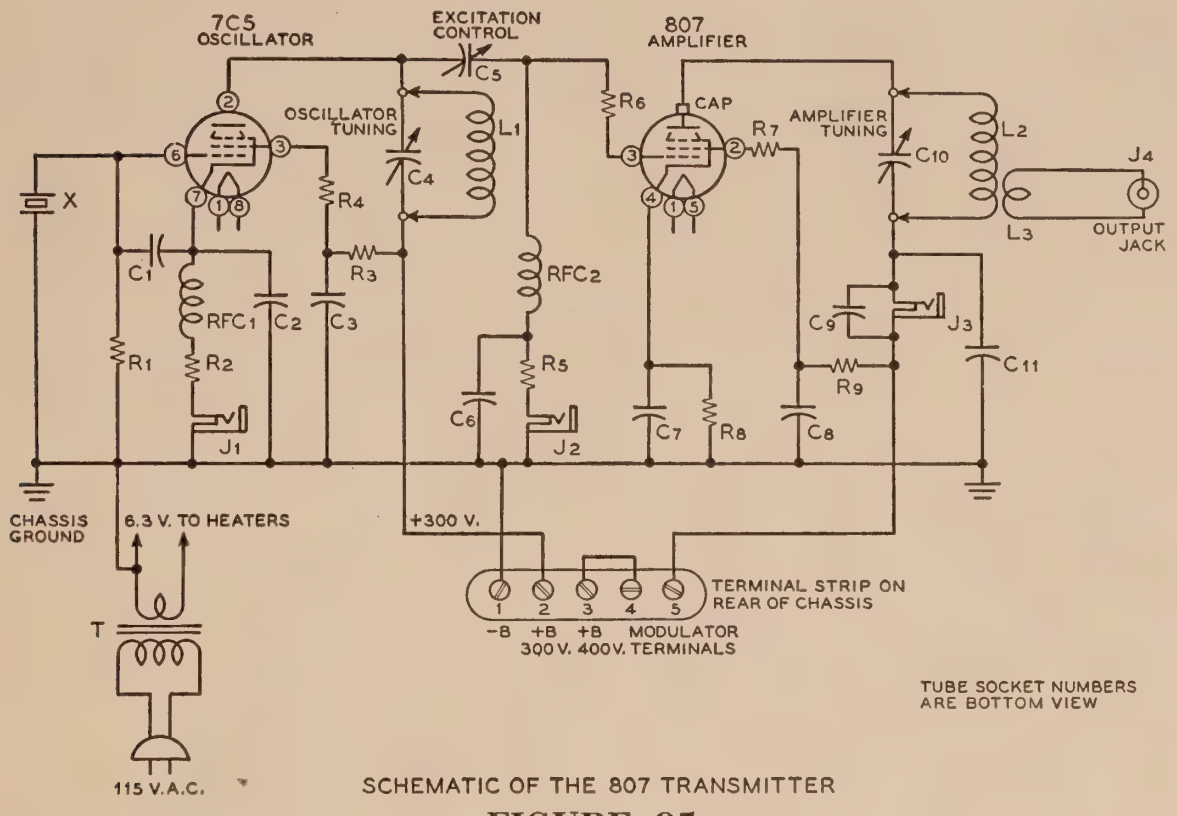


FIGURE 94
Under-Chassis View of 40 watt Transmitter.



SCHEMATIC OF THE 807 TRANSMITTER

FIGURE 95

C1—0.00004 mfd. mica capacitor
C2—0.00025 mfd. mica capacitor
C3—0.002 mfd. mica capacitor
C4—100 mmfd. midget variable capacitor
C5—50 mmfd. midget variable capacitor
C6—0.005 mfd. mica capacitor
C7, C8, C9—0.005 mica capacitors
C10—100 mmfd. transmitter-type variable capacitor (0.026-inch plate spacing).
C11—0.005 mfd. mica capacitor
J1, J2, J3—Midget closed-circuit jacks
J4—Coaxial r. f. output jack
L1—Oscillator coil (See Figure 96)
L2, L3—807 plate and end-link coil combination. Manufactured coil assembly, such as Millen Type 44040, for 10-, 20-, 40-, and 80-meter bands.
R1—100,000 ohm ½ watt resistor
R2—150 ohm 5 watt resistor
R3—10,000 ohm 1 watt resistor
R4—50 ohm ½ watt resistor
R5—10,000 ohm 1 watt resistor
R6, R7—50 ohm 1 watt resistors
R8—300 ohm 5 watt resistor
R9—40,000 ohm 10 watt resistor
RFC1, RFC2—2½ m. h. radio-frequency chokes
T—6.3 v., 2 A. filament transformer
XTAL—Crystal

tor stage. An external power supply (See Figure 97) is employed, and an external modulator (See Figure 98) is used.

Mechanical The transmitter is built on a metal chassis; 17 inches long, 7 inches wide, and 3 inches high. Open-chassis type of construction is employed, but the reader may enclose the entire rig in a metal or wooden cabinet if he desires.

Plug-in coils are used in both oscillator and amplifier stages. The oscillator coils are wound on 1¼-inch-diameter polystyrene forms which are plugged into a 4-contact socket and covered by the 2½-inch-diameter can-type metal shield seen directly behind the 7C5 tube in Figure 93. This shield can is held to the chassis by four thumbscrews and is replaced each time the oscillator coil is changed. The manufactured plug-in coils for the 807

FIGURE 96. OSCILLATOR COIL TABLE

80-METER BAND. 30 turns No. 20 d.c.c. wire closewound on a 1½"-diameter form.

40-METER BAND. 16 turns No. 20 d.c.c. wire on a 1½"-diameter form. Space to a winding length of 1½ inch.

20-METER BAND. 8 turns No. 20 d.c.c. wire on a 1½"-diameter form. Space to a winding length of 1½ inch.

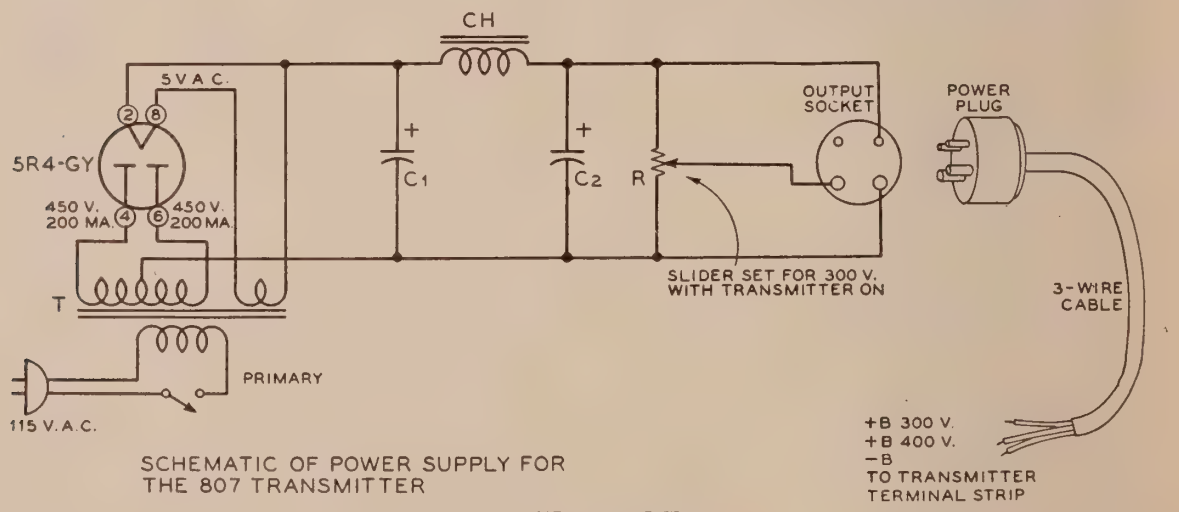
10- and 11-METER BANDS. 6 turns No. 16 enamelled wire on a 1½"-diameter form. Space to a winding length of 1½ inch.

amplifier come equipped with link coupling coils and are supplied with an insulating plug-in base which is mounted just to the right of the amplifier tuning capacitor (C_{10} in Figure 95), where it may be seen in Figure 93. The 80-meter coil is shown in the photograph.

Another 2½-inch-diameter shield can surrounds the 807 tube (See Figure 93). Both of these shield cans are most important to proper operation of the transmitter and must not be omitted by the builder.

Jacks J_1 and J_2 are mounted directly through the front lip of the chassis (See Figure 93), since they do not require insulation. Jack J_3, however, carries high voltage and must not only be insulated from the chassis but must be placed out of the operator's reach. In Figure 93, this jack may be seen mounted on a small bakelite sub-panel under the chassis and back from the front. The meter plug must be inserted through the large clearance hole seen on the right-hand end of the chassis in Figure 93. This jack assembly also is visible in the under-chassis photograph, Figure 94. The coaxial r. f. output jack, J_4, needs no insulation, therefore it is mounted directly through the rear lip of the chassis, and may be seen clearly in Figure 94. A matching coaxial plug at the end of a length of coaxial cable is inserted into this jack to connect the transmitter to the antenna or antenna coupler.

Each of the tuning capacitors (C_4 and C_{10}) and the coupling capacitor, C_5, likewise must be insulated from the chassis. Capacitors C_4 and C_5 are



SCHEMATIC OF POWER SUPPLY FOR THE 807 TRANSMITTER

FIGURE 97

C1, C2—10 mfd. 600 d. c. w. v. tubular electrolytic capacitors

CH—15 henry 250 ma. filter choke

R—25,000 ohm 100 watt wirewound resistor with slider

S—Single-pole, single-throw toggle switch

T—Power transformer

mounted together on a small polystyrene sub-panel supported from the front lip of the chassis by four metal studs (See Figure 94) and are connected to the tuning dials through flexible coupling and bakelite rods, also visible in Figure 94. The amplifier tuning capacitor, C_{10}, is mounted atop long ceramic posts on top of the chassis (See Figure 93) and is tuned by means of the large bakelite knob seen in that photograph.

The high-voltage lead from C_{10} and L_2 is connected to a ceramic-insulated feed through terminal, seen on the extreme right-hand end of the chassis in Figure 93, in order to connect this capacitor and coil to the wiring under the chassis. A short length of 2-wire 75-ohm flat r. f. conductor passes from the link contacts on the amplifier plug-in coil base through a grommet-lined hole in the chassis, and is connected directly to the coaxial output jack. This line may be seen in Figure 94 as it passes through the insulated hole and connects to the jack.

Filament transformer T is mounted under the chassis, where it may be seen in one corner in Figure 94.

The crystal is plugged into a special 2-contact, ceramic-insulated crystal socket which may be seen, with crystal, on the left-hand end of the chassis in Figure 93.

Power supply and modulator connections are made to terminals on an insulated strip mounted on the back lip of the chassis.

Circuit The complete circuit wiring is shown in Figure 95. In this arrangement, jack J_1 is provided for insertion of a milliammeter for reading the oscillator cathode current or for the insertion of a key. Jack J_2 is for reading the amplifier grid current, and jack J_3 for reading amplifier plate current. When the meter plug is removed from either one of these jacks, the circuit is automatically restored.

The variable coupling capacitor, C_7, is used as an excitation control which permits adjustment of the 807 amplifier grid milliamperes (read with the milliammeter plugged into jack J_2) to the precise value recommended for the 807 tube.

A separate filament transformer, T, (See Figures 94 and 95) is employed for heating the 7C5 and 807 tubes.

The output leads from an external modulator are connected to terminals 4 and 5 on the rear-chassis terminal strip. When c. w. telegraphy is used, disconnect the modulator leads and connect terminals 4 and 5 together by means of a wire jumper.

Several types of operation are obtainable with this transmitter. For example; 80-meter operation may be obtained by plugging-in an 80-meter crystal, 80-meter oscillator coil, and 80-meter amplifier coil.

40-meter operation may be obtained by means of a 40-meter crystal, 40-meter oscillator coil, and 40-meter amplifier coil.

40-meter operation also may be obtained with 80-meter crystal, 40-meter oscillator coil, and 40-meter amplifier coil.

20-meter operation may be obtained with 20-meter crystal, 20-meter oscillator coil, and 20-meter amplifier coil.

10-meter operation may be obtained with 10-meter crystal 10-meter oscillator coil, and 10-meter amplifier coil.

10-meter operation may be obtained also with 40-meter crystal, 20-meter oscillator coil, and 10-meter amplifier coil.

11-meter operation may be obtained with either of the schemes listed for 10-

meter operation, except that the crystal frequency must so be chosen that its useable harmonic will lie in the 11-meter band.

Thus, the several methods of operation will suit the various common amateur crystals. While it is possible to quadruple frequency both in the oscillator and amplifier stages, this procedure does not give the highest efficiency of which this transmitter is capable, and accordingly is not recommended except for emergency use.

Adjustment and Operation With antenna disconnected from the transmitter, connect a jumper between terminals 4 and 5 on the rear-chassis terminal strip. Plug-in crystal and coils for one of the combinations listed in the preceding paragraphs, connect and switch-on the power supply unit, and allow about 2 minutes for tubes to heat.

Connect a 0-10 d. c. milliammeter to jack J_2 and tune capacitor C_4 for maximum upward swing of the meter. Adjust capacitor C_5, readjusting C_4, until the maximum meter reading at this upswing is not more than 5 milliamperes.

Connect a 0-100 d. c. milliammeter to jack J_3 and adjust tuning capacitor C_{10} for dip in the meter reading. Do not permit the transmitter to run very long in this condition, since the 807 does not react favorably to prolonged tuning without the antenna.

Connect the coaxial line from the antenna or antenna coupler to jack J_4 and retune C_{10} for dip, which this time will be in the neighborhood of 100 milliamperes with the antenna taking full load. Retune also C_4 and C_5, as required.

For c. w. telegraphy, plug the key into jack J_1. For voice transmission, remove the jumper from terminals 4 and 5 on the rear-chassis terminal strip and connect in its place the output leads from the external modulator unit. Tune-up the transmitter in the manner just described. Turn-on the modulator and speak into the microphone, monitoring your voice signals either with your receiver (volume turned low and no receiving antenna) or with the simple listening monitor shown in Figures 51 and 99. Check the actual percentage modulation according to one of the schemes explained in the question and answer chapter of this book. Adjust the modulator gain control for 100-percent modulation and best voice quality.

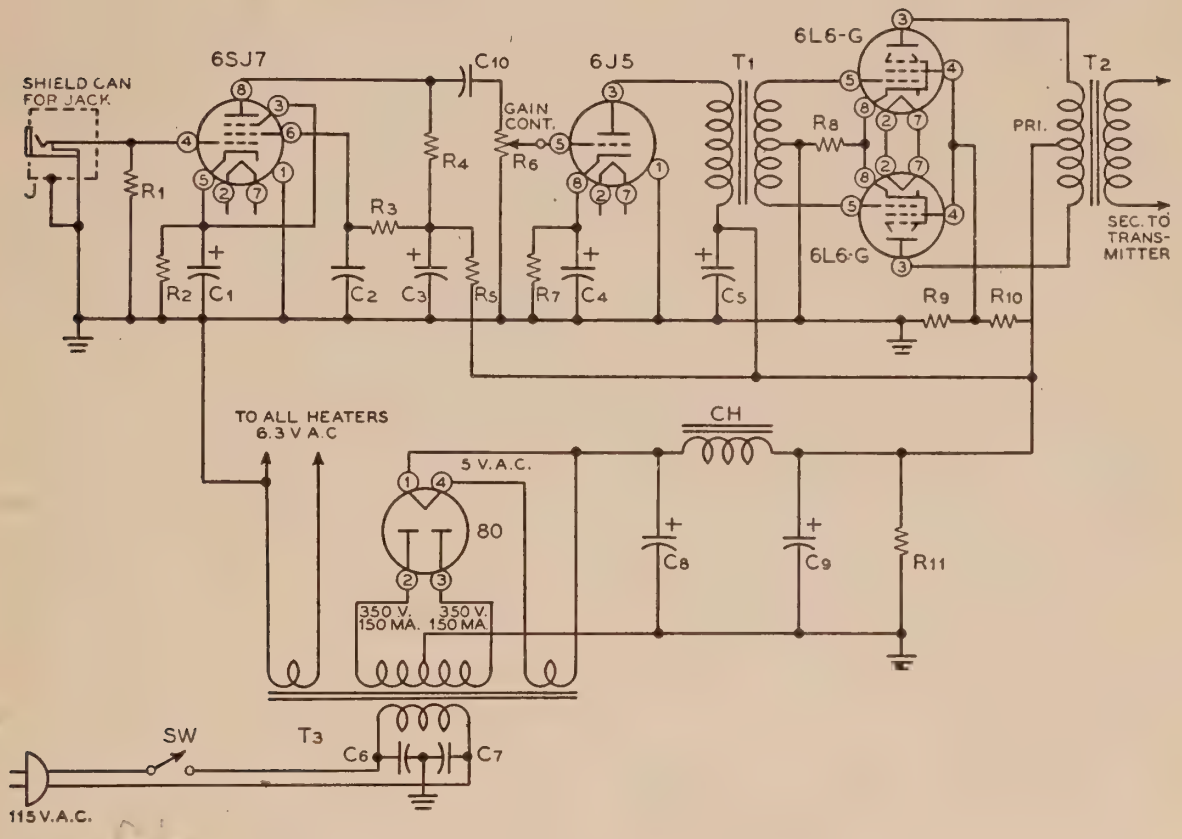
External Modulator Figure 98 shows the circuit diagram of a suitable modulator for this transmitter. This modulator has an audio power output of approximately 24 watts which affords a small power reserve. The entire unit, including its self-contained power supply, may be built on a 17"x10"x2" metal chassis and may be enclosed in a cabinet, if desired.

It is very important that this modulator be built ruggedly and that the microphone, J, be enclosed in a small metal can to prevent r. f. pickup from the transmitter.

The modulator has been designed for use with a diaphragm-type crystal microphone such as the one shown in Figure 23, and the operator is advised to use this sort of microphone for best results.

2-Meter Transmitter

A small 2-meter transmitter is shown in Figures 101 and 102. This interesting and effective transmitter may be operated either from an external a. c. power supply delivering 300 volts d. c. and 6.3 volts a. c.—or from a 6-volt



SCHEMATIC OF MODULATOR FOR 40-WATT TRANSMITTER

FIGURE 98

C1—20 mfd. 50 d. c. w. v. tubular electrolytic capacitor
C2—0.1 mfd. 400 v. tubular capacitor
C3—8 mfd. 450 d. c. w. v. tubular electrolytic capacitor
C4—20 mfd. 50 d. c. w. v. tubular electrolytic capacitor
C5—8 mfd. 450 d. c. w. v. tubular electrolytic capacitor
C6, C7—0.1 mfd. 400 v. tubular capacitor
C8, C9—10 mfd. 450 d. c. w. v. tubular electrolytic capacitor
C10—0.01 mfd. mica capacitor
CH—10 henry 150 ma. filter choke
J—Midget closed-circuit (normally closed) jack with small metal shield can
R1—5 megohm ½ watt resistor
R2—2000 ohm 1 watt resistor
R3—2 megohm ½ watt resistor
R4—500,000 ohm 1 watt resistor
R5—50,000 ohm 1 watt resistor
R6—1 megohm potentiometer
R7—1500 ohm 1 watt resistor
R8—250 ohm 10 watt wirewound resistor
R9—10,000 ohm 20 watt wirewound resistor
R10—2000 ohm 10 watt wirewound resistor
R11—50,000 ohm 10 watt wirewound resistor
S—Single-pole, single-throw toggle switch
T1—Interstage audio transformer. Single plate to pushpull grids. 2 to 1 ratio.
T2—25-watt modulation transformer. Primary impedance 9000 ohms plate to plate; secondary impedance 4000 ohms.
T3—Power transformer (See Figure 98 for specifications).

storage battery and six to seven 45-volt "B" batteries series-connected. It may be operated also from any of the 6-volt portable power supplies, such as Vibrapacks and motor-generators. This enables the operator to use this transmitter either at home or in the field. The self-contained 6V6-G modulator and 6J5 speech amplifier accomodate a carbon microphone.

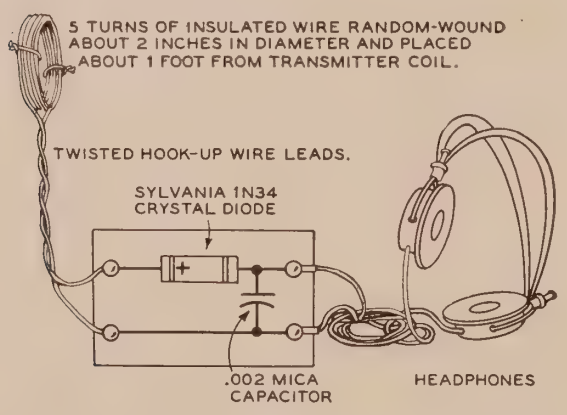
This ultra-high-frequency transmitter may be used in conjunction with the superregenerative receiver described in the preceding chapter to make up a useful newcomer's u. h. f. phone station.

Construction The 2-meter transmitter is built on a 7"x10"x2" metal chassis. In the HY75 oscillator circuit, all components (such as C_1, C_2, L_1, L_2, RFC_1, and RFC_2) are grouped close together above chassis near the HY75 tube, in order to shorten all connecting leads. The remainder of the transmitter wiring, however, is below chassis.

Coil L_1 is mounted close to L_2 in such a way that bending the former from one side to the other will vary its distance from L_2.

The flashlight cell furnishing microphone current is held below chassis by means of a curved springy metal strip. Since this cell will not have to be replaced often, connections from microphone jack J and transformer T_1 may be soldered directly to its terminals, simplifying that portion of the construction. When the transmitter is shut down, removal of the microphone plug from jack J will disconnect the dry cell automatically and prevent unnecessary drain.

Switch S in the B-minus lead allows the transmitter to be shut off during listening periods without extinguishing the tube heaters.


5 TURNS OF INSULATED WIRE RANDOM-WOUND ABOUT 2 INCHES IN DIAMETER AND PLACED ABOUT 1 FOOT FROM TRANSMITTER COIL.
TWISTED HOOK-UP WIRE LEADS.
SYLVANIA 1N34 CRYSTAL DIODE
.002 MICA CAPACITOR
HEADPHONES

SIMPLE LISTENING MONITOR FOR VOICE SIGNALS

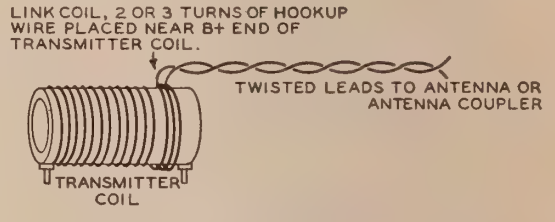
FIGURE 99

Adjustment and Operation Place the 2-meter superregenerative receiver into operation. After all transmitter wiring has been checked, connect a power supply unit to the transmitter power plug. This may be a power supply of the type shown in the receiver chapter of this book. After allowing the tubes to heat, close switch S, without connecting an antenna to the ANTENNA TERMINALS of the transmitter and tune-in the transmitter signal on the superregenerative receiver (without receiving antenna). The receiver dial must have been calibrated to show the limits of the amateur 2-meter band.

Tune C_1 over its entire range, observing with the receiver which of these capacitor settings correspond to points within the 2-meter band. It may be necessary to squeeze the turns of L_2 together slightly or to separate them somewhat, in order to cover the band satisfactorily.

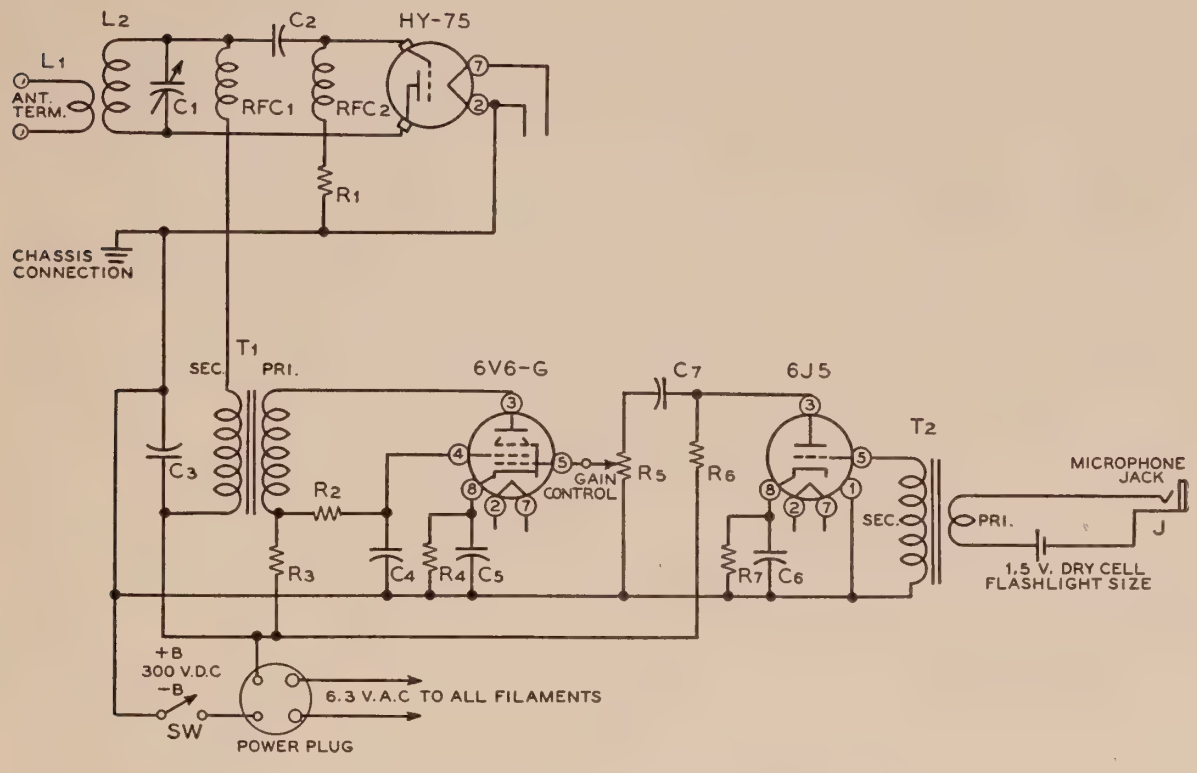
Connect the transmitting antenna to the ANTENNA TERMINALS, continuing to listen to the signal. If there is severe detuning of the signal when the antenna is connected, increase the spacing between coils L_1 and L_2.

Insert the microphone plug into jack J, turn up the gain control, R_5, and speak into the microphone. Listen to


LINK COIL, 2 OR 3 TURNS OF HOOKUP WIRE PLACED NEAR B+ END OF TRANSMITTER COIL.
TWISTED LEADS TO ANTENNA OR ANTENNA COUPLER
TRANSMITTER COIL

METHOD OF COUPLING TRANSMITTER COIL TO ANTENNA.

FIGURE 100



SCHEMATIC OF THE 2-METER TRANSMITTER

FIGURE 101

C1—Midget 15-mmfd. variable capacitor
C2—100-mmfd. mica capacitor
C3—8-mfd. 450 d. c. w. v. tubular electrolytic capacitor
C4—0.25-mfd. 600-v. tubular capacitor
C5—25-mfd. 25 d. c. w. v. tubular electrolytic capacitor
C6—10-mfd. 25 d. c. w. v. tubular electrolytic capacitor
C7—0.01-mfd. mica capacitor
J—Midget single-circuit (normally open) phone jack
L1—2 turns No. 14 enamelled wire ½" in diameter, spaced slightly. Mount about ⅛" from L2.
L2—3½ turns No. 14 enamelled wire ½" in diameter. Spacing between turns equal to diameter of wire.
R1—5000 ohm 10 watt resistor
R2—30,000 ohm 1 watt resistor
R3—2000 ohm 50 watt resistor
R4—500 ohm 2 watt resistor
R5—500,000 ohm potentiometer
R6—100,000 ohm 1 watt resistor
R7—2000 ohm 1 watt resistor
RFC1, RFC2—Ohmite Type Z-1 u. h. f. chokes
T1—10 watt modulation transformer. Primary impedance 10,000 ohms; secondary impedance 5000 ohms.
T2—Microphone transformer

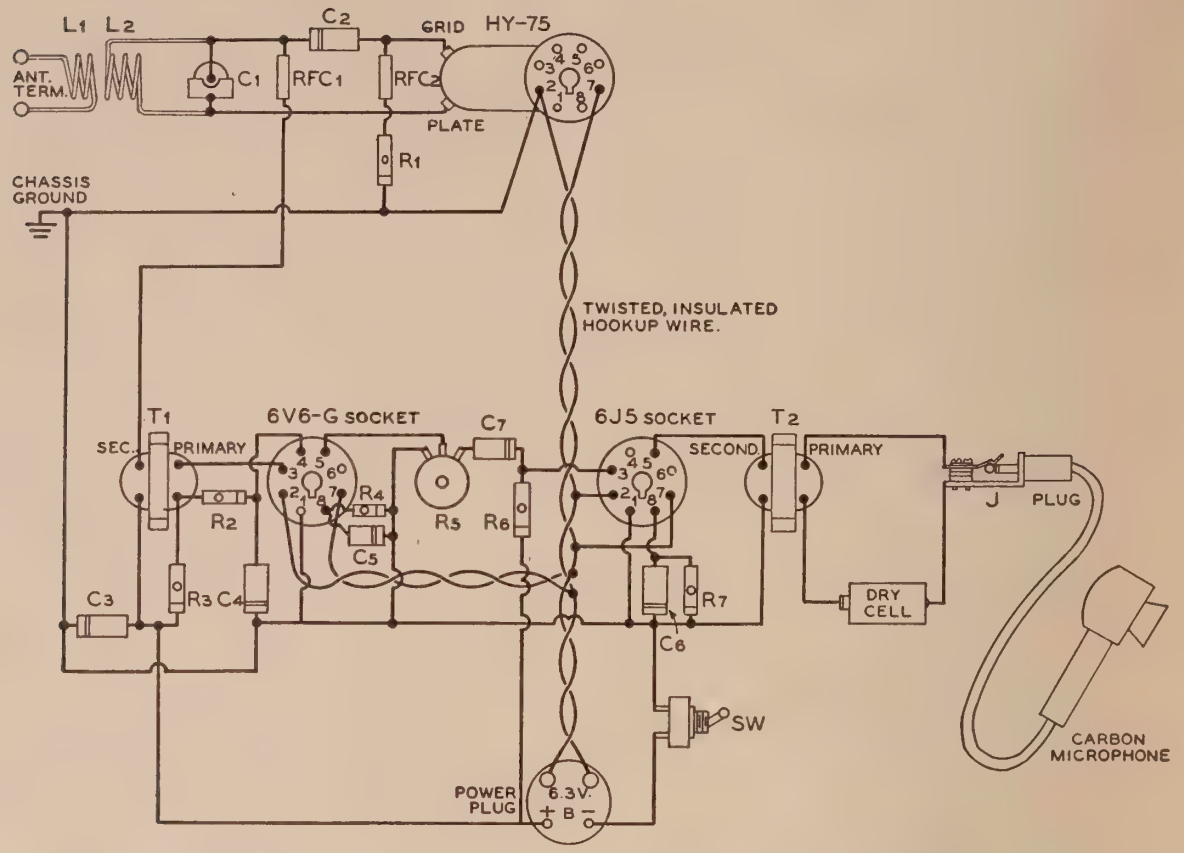
your voice signals with the receiver and with the simple listening monitor shown in Figure 99. Set gain control R_5 for the best voice quality and strongest signals. Check the actual modulation percentage according to one of the schemes explained in the question and answer chapter of this book.

During listening periods, throw switch S to its OFF position. This will shut the transmitter off and prevent interference with the receiver.

Auxiliary Test Devices for Transmitters

Lamp-Type R. F. Indicators

Neon and filament-type lamps are handy for detecting radio-frequency voltages in transmitters. These two devices are shown in Figure 103. The left-hand device is a 2-watt neon lamp. On the right-hand side is shown a 2-volt pilot



PICTURE WIRING DIAGRAM OF THE 2-METER TRANSMITTER

FIGURE 102

lamp to which has been connected a 1-turn loop of wire.

To find out if a transmitter is generating r. f. voltage, hold the neon lamp by its glass bulb and touch its solder tip to the coil in the transmitter circuit under test. The neon glow will appear only if r. f. is present. In a strong r. f. field (as around a briskly operating transmitter), the glow will appear even when the neon lamp is in the vicinity of the coil—without any physical connection to the coil.

The same test may be made with the pilot lamp and loop. Most amateurs prefer this device, since no con-

FIGURE 103
Neon bulb and dial light-loop used in tuning transmitters.

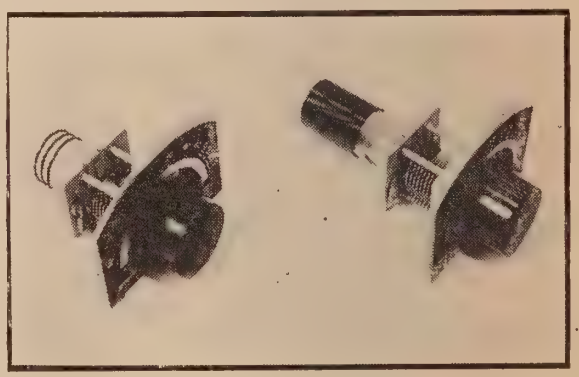


FIGURE 104
Manufactured wavemeters. Dials calibrated directly in frequency.

nection is required between the test device and transmitter coil. The loop is coupled to the transmitter merely by holding it near the transmitter coil. The lamp will light to indicate the presence of r. f. Be careful in making this test not to hold the lamp loop too close to the transmitter coil, since a strong r. f. field will burn out the lamp.

Both of these simple devices are invaluable as tuning indicators. In the absence of a milliammeter for the transmitter, tuning may be accomplished by adjusting for maximum brilliance of the lamp. Either the neon bulb or the lamp-and-loop may be employed.

Wavemeters Simple absorption wavemeters are illustrated in Figure 104. These instruments are used to measure transmitter frequency and are especially useful for determining if a frequency multiplier stage is operating at the proper harmonic.

A wavemeter is simply a coil and variable capacitor connected in parallel and provided with a calibrated dial scale. It will be seen from Figure 104 that the wavemeter dial is graduated directly in kilocycles or megacycles.

Operate the wavemeter in this manner: With the transmitter operating, hold the wavemeter close to the transmitter so that the wavemeter coil and transmitter coils are coupled. Tune the wavemeter until the transmitter milliammeter shows a sharp flick. Increase the distance between transmitter and wavemeter coils until this flick occurs at a sharply defined setting of the wavemeter dial. When operation is sharp and positive, both wavemeter and transmitter are tuned to the same frequency—and the "unknown" frequency then may be read directly from the wavemeter dial.

The newcomer is advised to buy a set of factory-built wave-meters. It is better not to attempt the calibration of a set of home-made instruments until he has gained more experience in radio.

CHAPTER EIGHT

Amateur Antennas

An antenna is needed to radiate signals from the transmitter. While any length of wire insulated from its supports, installed as high in the air as possible, and with one end connected to the receiver, usually will be sufficiently effective for receiving purposes, transmitting antennas must conform to certain general designs in order to radiate power efficiently. In this chapter, we describe several amateur transmitting antennas which may be used successfully with the transmitters shown in the preceding chapter.

Antenna Parts and Dimensions The transmitting antenna is divided into two main parts. The portion that actually delivers the signal to the "air" is known as the *radiator.* The portion conducting power to the radiator from the transmitter is termed the *feeder,* and sometimes the *transmission line.*

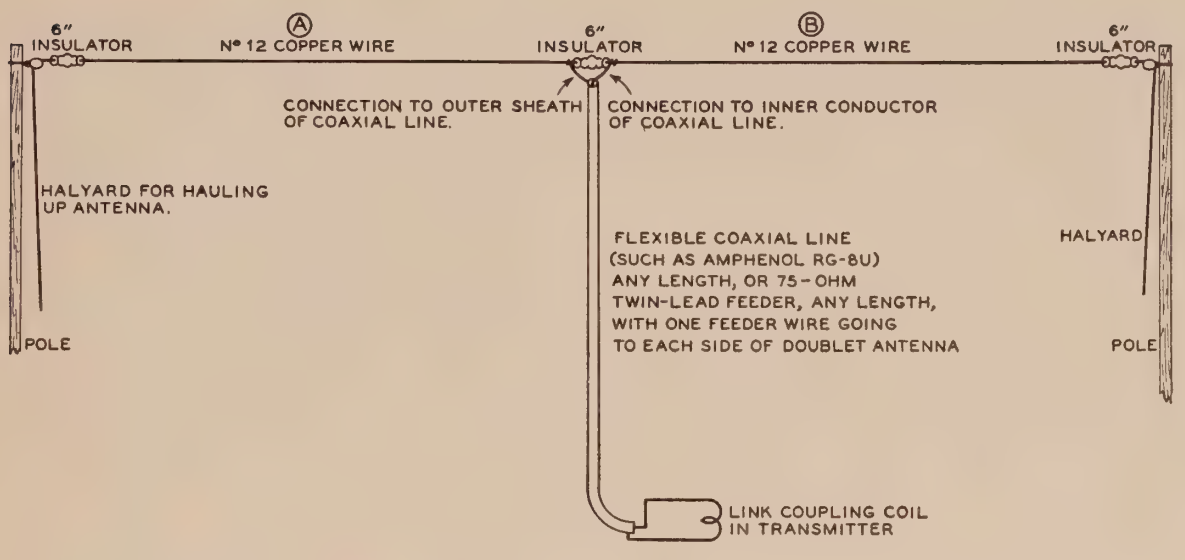
The radiator usually is horizontal for frequencies below 50 Mc. and consists of a length of wire fastened to insulators at each end and supported from the tops of high poles or masts. At amateur ultra-high frequencies, however, it often is desirable to mount the radiator vertically. The feeder may be connected to the radiator at the latter's center or at one end, depending upon the type of antenna, the type of feeder, and the method of matching the feeder to the radiator.

Unlike the receiving atenna, the radiator of the transmitting antenna must be cut to a definite length for best results. Thus; the length of the *entire* radiator in the antennas illustrated in this chapter must be a *half wavelength* at the transmitting frequency. The required length of a half-wave radiator element (in feet) may be determined by dividing 468 by the frequency (in megacycles).

An untuned feeder, like the simple coaxial or twin-lead cable shown in Figures 105, 108 and 109, may be any reasonable length. The two wires in the open-wire ("Zepp") feeder, such as shown in Figures 106 and 107A, however, must be cut to definite dimensions. These wires each should be at least ¼ wavelength long (or some multiple of a quarter wavelength) at the operating frequency. The required length of a quarter wave of open-wire line (in feet) can be found by dividing 240 by the frequency (in megacycles).

Coaxial and Twin-Lead vs. Open-Line Feeder The coaxial or 75-ohm twin-lead feeder offers extreme simplicity of both construction and operation. No antenna coupler is required with this type of feeder. Hence, the operation of tuning an antenna coupler is eliminated, and the cost of coupler parts saved. Furthermore, both coaxial cable and twin-lead feeder are neat and unobstructive in appearance.

But the antenna fed by coaxial cable or twin-lead has the distinct disadvantage that it can be used only in the band for which its radiator has been cut. It becomes necessary to lengthen


6" INSULATOR
Ⓐ
Nº 12 COPPER WIRE
6" INSULATOR
Ⓑ
Nº 12 COPPER WIRE
6" INSULATOR
CONNECTION TO OUTER SHEATH OF COAXIAL LINE.
CONNECTION TO INNER CONDUCTOR OF COAXIAL LINE.
HALYARD FOR HAULING UP ANTENNA.
FLEXIBLE COAXIAL LINE (SUCH AS AMPHENOL RG-8U) ANY LENGTH, OR 75-OHM TWIN-LEAD FEEDER, ANY LENGTH, WITH ONE FEEDER WIRE GOING TO EACH SIDE OF DOUBLET ANTENNA
HALYARD
POLE
POLE
LINK COUPLING COIL IN TRANSMITTER

CENTER-FED "DOUBLET" ANTENNA WITH COAXIAL OR TWIN-LEAD FEEDER

FIGURE 105

or shorten the radiator, as the case may be, if the transmitter is to be operated in other bands.

The half-wave antenna fed by a 2-wire open-line Zepp feeder can, on the other hand, be cut for the lowest-frequency band in which the transmitter will be operated (say, 80 meters) and it then may be operated in all higher-frequency bands (say, 10, 20, and 40 meters). However, an antenna coupler is required for tuning the open wire-fed antenna.

A simple all-band antenna (that is, one for 10-, 20-, 40-, and 80-meter operation) may be made with open-line feed, as will be explained later in this chapter.

U. H. F. Antennas For best efficiency, it usually is desirable to use special antennas for the amateur ultra-high frequencies. These antennas usually are mounted in such a way that their radiators are vertical. Such antennas are shown in Figures 108 and 109. The first is a simple coaxially-fed vertical half-wave antenna for use in the amateur 6-meter band. The second is a special 2-meter vertical antenna known as a *modified ground-plane antenna.* Working dimensions are given in the sections describing these antennas.

Antenna Mechanics The transmitting antenna must employ good quality insulators and must be mounted as high as possible above ground, houses, trees, and other surrounding objects. Care should be given to the job of erecting the antenna sturdily to prevent its swinging in the wind. The newcomer must realize that a good antenna is an essential part of the transmitting station —one which cannot be built properly except at the expense of considerable labor and forethought.

The feeder, of whatever type, must be brought straight away from the radiator in the most direct manner possible. The feeder also must be placed well away from other wires, and must be pulled as tightly as possible without distorting the radiator.

Coaxial feeder lines offer no particular problem as regards bringing them

into the transmitter building. The coaxial line is approximately ½ inch in diameter and accordingly may be pulled through a small round hole bored in a window sill or sash. Any common bushing or filler may be used to keep rain and wind from entering the hole.

The two wires of an open-line feeder pose an important insulation problem. To begin with, they must be kept uniformly separated throughout their entire length. For this purpose, "spreader insulators" (See Figures 106 and 107) are employed. These insulator bars are made of plastic or ceramic materials and are attached between the two wires every 2 or 3 feet.

The two wires must be well insulated as they enter the transmitter building. Either they must be pulled through *glazed* porcelain tubes—or, better still, they must be connected to the interior of the building by means of bowl-type transmitting feed-through terminals. The 6-inch spacing of the line must be preserved right up to the antenna coupler connections.

Transmitting Antenna for Receiving Usually, reception will be much better with the transmitting antenna than with a makeshift receiving antenna.

For this purpose, a single- or double-pole, double-throw switch may be provided to connect the antenna first to the transmitter then to the receiver.

Transmit-receive switching is discussed in more detail in the next chapter, "Assembling the Amateur Station."

Simple Doublet Antenna Figure 105 shows a simple half-wave antenna fed by a length of coaxial cable or 75-ohm twin-lead feeder. The feeder line may be any required length and its lower end may be connected directly to the link-coupling coil in the transmitter. No antenna coupler of any other kind is required. However, this is strictly a one-band antenna.

The two sections A and B of the radiator each are ¼ wave-length long

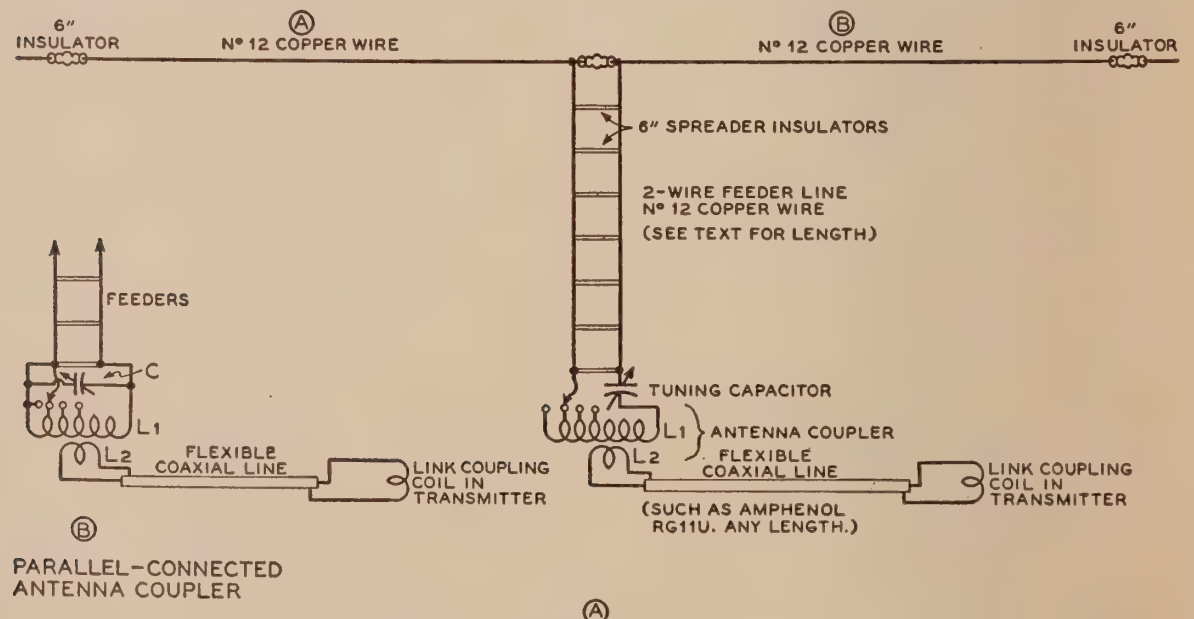


FIGURE 106

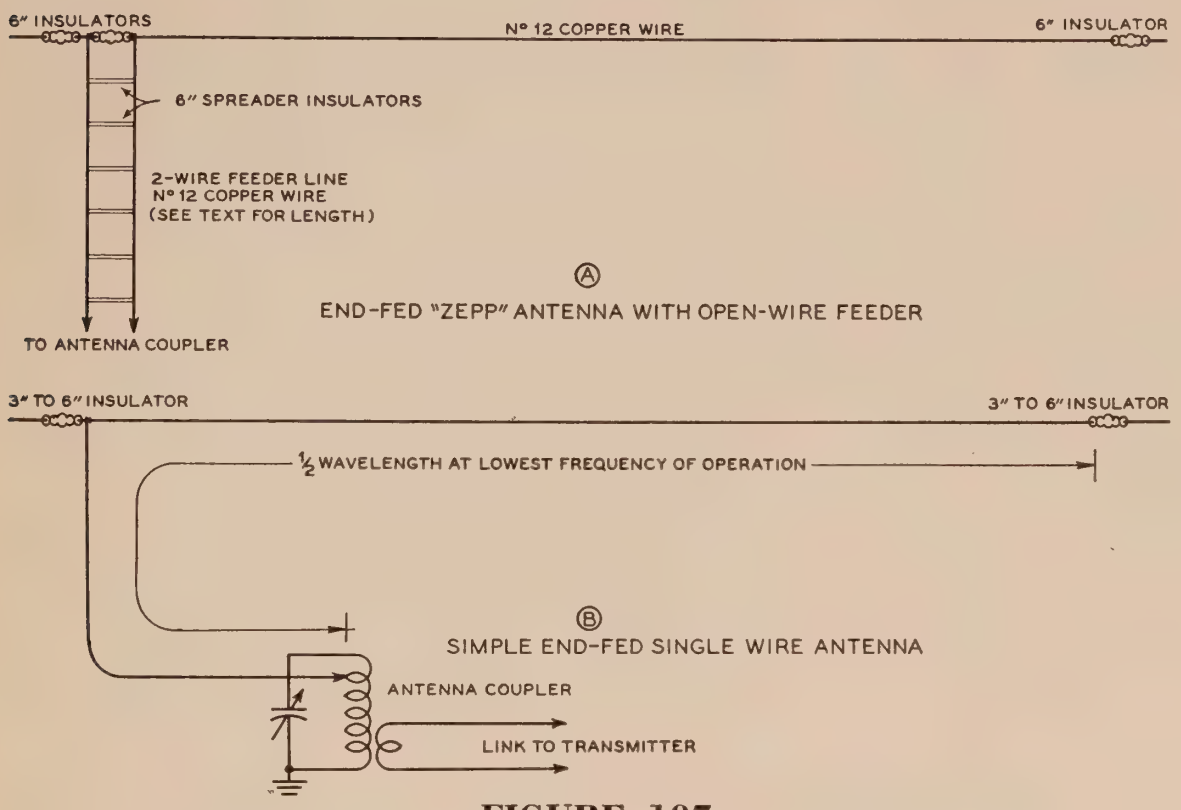


FIGURE 107

and are made of No. 12 copper wire. Each length must be measured carefully. One length is connected to the inner conductor of the coaxial cable and the other length to the outer conductor of the cable. If 75-ohm twin-lead cable is used, one length is connected to one twin-lead wire and the other length to the other twin-lead wire. Solder all connections.

Sections A and B each will have the following length for the lowest frequency in each indicated band:

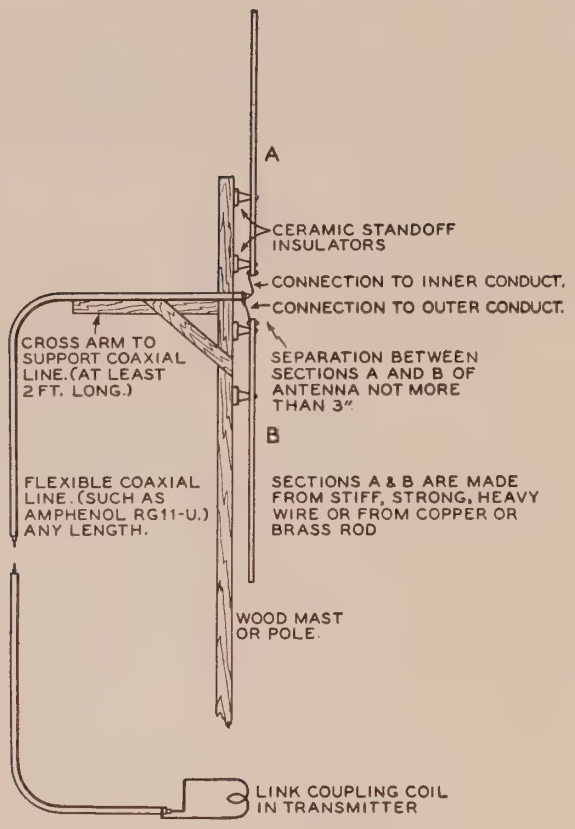
80 METERS. 67 feet
40 METERS. 33 feet, 6 inches
20 METERS. 16 feet, 8½ inches
10 METERS. 8 feet, 4½ inches

The antenna will be most effective at the particular frequency for which its radiator is cut (in the above cases; 3500, 7000, 14,000, and 28,000 kc.). If the builder desires, he mav cut sections A and B for the *center* frequency in each amateur band (using the formula given under "Antenna Parts and Dimensions"). Remember, however, that the lengths of A and B each must be *half* of the length calculated with the formula.

Half-Wave Center-Fed Zepp Antenna Figure 106 shows a type of Hertz antenna which is very popular with hams. Here, as in the preceding case, the two sections A and B of the radiator are carefully measured lengths of No. 12 copper wire. The dimensions of A and B for the 10-, 20-, 40-, and 80-meter bands will be the same as those given in the preceding section for the simple doublet antenna.

The feeder line consists of two lengths of No. 12 copper wire separated by means of 6-inch spreader insulators spaced every 2 or 3 feet apart throughout the entire length of the feeders.

This type of antenna requires an antenna coupler consisting of a coil L_1


A
CERAMIC STANDOFF INSULATORS
CONNECTION TO INNER CONDUCT.
CONNECTION TO OUTER CONDUCT.
CROSS ARM TO SUPPORT COAXIAL LINE. (AT LEAST 2 FT. LONG.)
SEPARATION BETWEEN SECTIONS A AND B OF ANTENNA NOT MORE THAN 3"
B
FLEXIBLE COAXIAL LINE. (SUCH AS AMPHENOL RG11-U.) ANY LENGTH.
SECTIONS A & B ARE MADE FROM STIFF, STRONG, HEAVY WIRE OR FROM COPPER OR BRASS ROD
WOOD MAST OR POLE.
LINK COUPLING COIL IN TRANSMITTER

6-METER VERTICAL ANTENNA

FIGURE 108

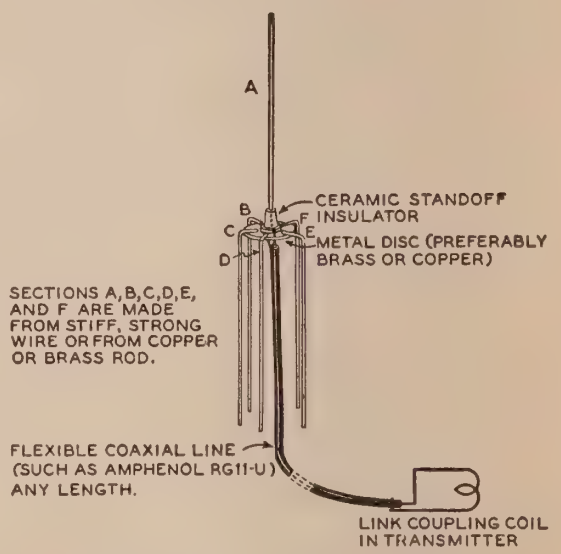
link coupled to the transmitter, and a variable tuning capacitor. Several taps must be soldered to L_1 to allow for close adjustment of coupling. The small link coupling coil L_2 consists of 3 to 5 turns of the same size wire as L_1. The antenna coupler must be arranged for easy shifting of its connections to allow series connection (shown in Figure 106A or parallel connection (shown in Figure 106B).

It is a good plan to make coil L_1 in the antenna coupler an exact duplicate of the output coil in the transmitter, and to employ a 100- to 250-mmfd. variable tuning capacitor.

Figure 110 shows a simple manufactured antenna coupler. The 80-meter coil is shown plugged-in in the photograph. These coils have center-link coupling coils which may be swung in or out of the split main coil, as may be seen from Figure 110, in order to vary the coupling to the transmitter. Connections between parts in this simple antenna coupler may be arranged for quick shifting, so as to change from series tuning to parallel tuning as desired (See Figure 106). Separate plug-in coils are employed for each amateur band. However; if a 200-mmfd. tuning capacitor is used, a 40-meter coil will cover both the 40- and 80-meter bands, and a 10-meter coil will cover both the 10- and 20-meter bands.

The feeder line should be at least ¼ wavelength at the lowest frequency at which the antenna will be used. You can calculate the length of wire (in feet) required for each feeder by dividing 240 by the frequency (in megacycles).

A particular advantage of the antennas of the type shown in Figures 106 and 107 is the fact that if they are cut for operation in the lowest-frequency amateur band, they may be used also in the higher-frequency bands. This makes it possible to obtain multi-band operation with a single antenna.


A
B
C
D
E
F
CERAMIC STANDOFF INSULATOR
METAL DISC (PREFERABLY BRASS OR COPPER)
SECTIONS A, B, C, D, E, AND F ARE MADE FROM STIFF, STRONG WIRE OR FROM COPPER OR BRASS ROD.
FLEXIBLE COAXIAL LINE (SUCH AS AMPHENOL RG11-U) ANY LENGTH.
LINK COUPLING COIL IN TRANSMITTER

EFFICIENT 2-METER ANTENNA

FIGURE 109

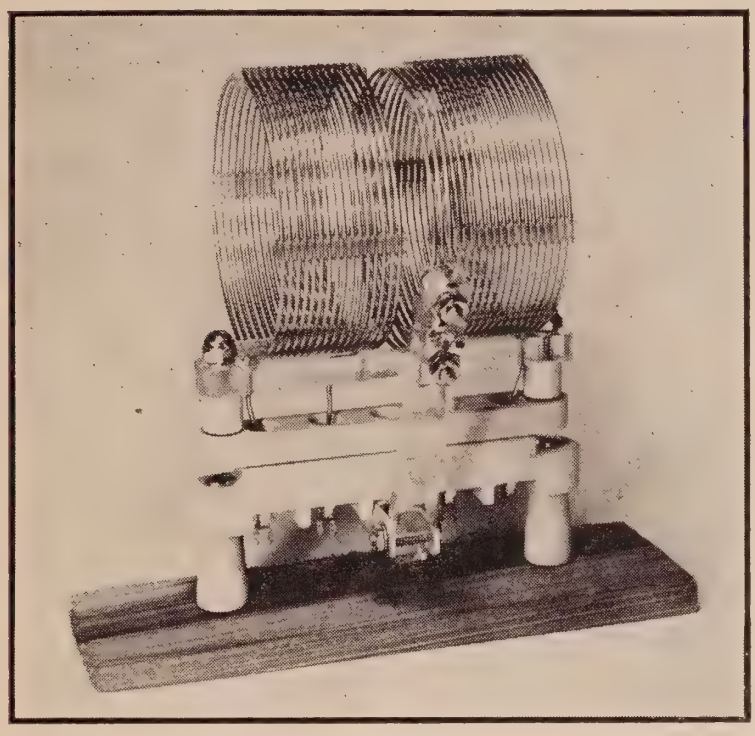


FIGURE 110
Manufactured plug-in 80 meter coil showing swinging loop method of antenna coupling. (James Millen Mfg. Co.)

A satisfactory multi-band center-fed antenna of the type shown in Figure 106 would have 68 feet 6 inches in each of its radiator wires (A and B) and 67 feet in each of its feeder wires. This antenna could be operated on 10, 20, 40, and 80 meters. Parallel tuning of the antenna coupler (See Figure 106B) would be used on all bands.

Tuning the Antenna Coupler First; tune-up the transmitter without any connection between transmitter and antenna coupler, according to directions given in Chapter 7. Adjust carefully for plate current dip in the transmitter output stage.

Now, connect the antenna coupler to the transmitter. Note that the plate current increases in value. Reduce the link coupling to the antenna coupler, if necessary, to lower the plate current to the recommended value, retuning the transmitter output stage. Or, increase the link coupling to the antenna coupler to increase the plate current if it happens to be lower than normal.

The antenna feeder line should now be connected successively to various taps on coil L_1 of the coupler until a point is found where tuning of the transmitter is *not* changed when the antenna is connected or disconnected, but plate current dip is merely increased to a higher value when the antenna is connected. This increased plate current value, as pointed out in Chapter 7, indicates that the antenna is drawing power. However, touching up the tuning controls of the transmitter will show that no retuning is necessary when the antenna is connected to the proper taps on coil L_1 of the antenna coupler.

Manufactured Antenna Couplers Several manufacturers of transmitter coils have made available plug-in coils for amateur antenna couplers. These coils cover the amateur bands, and come provided with taps to which a "travelling" clip lead may be attached. Most of these

coils are designed for use with a 200- to 300-mmfd. tuning capacitor and are relatively inexpensive.

By employing one of these manufactured antenna couplers, the newcomer can save himself the labor of building this unit—especially the job of soldering short tap wires on every second or third turn of the main coil.

Half-Wave End-Fed Antenna The antenna shown in Figure 106 is not easy to erect at all locations. This is because the transmitter building must be located right under the center of the radiator if the feeders are to fall directly down from the flat-top portion.

In a number of locations, it is far easier to run a feeder line to one end of the radiator. The end-fed Zepp antenna shown in Figure 107A allows such an end connection of the feeders. Here, the radiator wire is one continuous piece of wire, ½ wavelength in length, rather than two sections. The feeder wires, as in the center-fed antenna, each must be ¼ wavelength long—or some multiple of ¼ wavelength.

An antenna coupler must be employed also with the end-fed antenna. This coupler will have the same dimensions as the one described for the center-fed antenna.

In an all-band end-fed antenna, the radiator wire will be 136 feet long, and each of the feeder wires 67 feet long. Series tuning of the antenna coupler (See Figure 106A) will be necessary for 80-meter operation; parallel tuning (See Figure 106B) in the 10-, 20-, 40-, and 80-meter bands.

Probably the simplest satisfactory all-band antenna is that shown in Figure 107B. If such an antenna is made ½-wave long in the 80-meter band (measured from the far insulator to the antenna coupler) it will operate satisfactorily on the 80-, 40-, 20-, and 10-meter bands.

6-Meter Antenna Figure 108 shows a coaxially-fed half-wave antenna suitable for use in the amateur 6-meter band. It will be noted that this antenna is similar to the one shown in Figure 105, except that the 6-meter unit is mounted *vertically* and short, stiff wires or rods are used as radiators.

Designed for the center frequency of the 6-meter band, this antenna will perform well over the entire band, but has its top efficiency at about 52 megacycles. Each of the radiator rods, A and B, must be 4½ feet long. The rods are held away from the supporting mast or pole by means of high-grade ceramic "stand-off" insulators. As much of the top rod, A, as possible should extend above the top of the pole. The bottom ends of the rods should be separated by not more than 3 inches.

The top rod is connected directly to the inner conductor of the flexible coaxial line; the bottom rod to the outer conductor of the line. The line (cable) must run straight away (horizontally) from the antenna, as shown in Figure 108, for a distance of at least 2 feet. The cable may be supported by a horizontal cross arm, as shown, to meet this requirement.

The lower end of the coaxial cable is connected directly to the link coupling coil in the transmitter, no other antenna coupler being required. If trouble is experienced with the antenna detuning the transmitter, a 50-mmfd. variable capacitor may be connected in series with the inner conductor of the coaxial cable at the transmitter end, to overcome this effect.

The 6-meter antenna must be mounted as high in the air as possible

and well away from surrounding objects, such as buildings, trees, chimneys, wires, etc. It is a good idea to use the tallest supporting pole or mast that can be erected.

Tuning of the transmitter with and without the antenna must be carried out in the manner explained in Chapter 7.

2-Meter Vertical Antenna Figure 109 shows a 2-meter antenna of the modified *ground plane* type. This is another type of antenna fed in a simple manner by means of a coaxial line.

The 2-meter antenna has six sections or elements. Section A is a vertical rod exactly ¼ wavelength long, which is insulated from the other sections by means of a ceramic stand-off insulator on which it is mounted. Section A is connected directly to the center conductor of the coaxial cable.

Sections B, C, D, E, and F, each are rods of the same material and length as A. ⅛ or ¼ inch is a good diameter. Each of the lower sections is connected to each of the other lower sections by means of the metallic disc or plate to which they are attached. The plate is connected directly to the outer conductor of the coaxial cable. Each of the bottom rods is bent vertically downward so as to rest as closely as possible to the coaxial cable and mounting pole without coming into direct contact with either. Rods B, C, D, E, and F are spaced equally around the circumference of their mounting disc.

The top of the pole supporting this antenna is fastened directly to the bottom of the mounting disc, and the coaxial cable is run down the pole and in close contact with the latter. If a hollow metal pipe is employed as the mast, the coaxial cable may be run down through its interior and may emerge through a hole in the lower end of the pipe wall.

Designed for the center frequency of the amateur 2-meter band, this antenna will operate reasonably well throughout the entire band. Each of the rods (A, B, C, D, E, and F) will be 1 foot, 7½ inches in length—this length including the bend in Sections B, C, D, E, and F.

The 2-meter antenna must be mounted as high in the air as possible and clear of any nearby objects such as houses, trees, chimneys, wires, etc.

If any difficulty is experienced with the antenna detuning the transmitter, a 50-mmfd. variable capacitor may be connected in series with the inner conductor of the coaxial cable (at the transmitter end) and adjusted to eliminate this effect.

Additional Antenna Information We have made no attempt to discuss antenna theory in this chapter, nor to describe any antennas except specific types for use with the transmitters described in Chapter 7. For more detailed information on the general subject of antennas, the reader is referred to the antenna chapters in the *Radio Handbook*.

CHAPTER NINE

Assembling and Operating the Amateur Station

What Bands To Operate The newcomer, in order to use his low-power transmitting equipment most effectively, can profit by knowledge of the characteristics of the various amateur bands upon which he contemplates operation. The most satisfactory all-round band upon which to begin operation is probably the 40-meter c-w band. This band will be found to be usable all year around in the daytime for short-haul work from local contacts out to perhaps 500 miles. In the late evening contacts can be had on "40" out to 3000 miles with some degree of regularity, and international DX may be attained in the winter after midnight when the band is particularly good.

The 80-meter band will be found rather inactive with a high noise level, except on weekends when there is some daytime activity. However, "80" will be found to be quite good in the evening all year around for short-haul work, and late in the evening in the winter "domestic DX" contacts may be attained.

Operation on the 20-meter band by a newcomer is not recommended. After a degree of proficiency in operating has been attained, and perhaps after an amplifier of 50 to several hundred watts input has been added to the particular transmitter chosen from Chapter 7, the 20-meter band may be given a whirl. But the competition from high-power variable-frequency transmitters operating into high-gain directional antenna arrays will almost certainly discourage the newcomer. The characteristics of the band are, however, "domestic DX" winter and summer in the daytime, and international DX almost around the clock in the spring and fall of the year.

The 10-meter band will be found to be satisfactory for 1500 to 3000 mile contacts with low power on 'phone when the band is open.

Occasional international DX contacts will probably be possible in the morning and late afternoon when the band is active. Due to the high concentration of higher-powered stations in the range from 28,500 to about 29,200 kc. the newcomer will probably attain best results with an operating frequency between 29,200 kc. and 29,700 kc. When a 14-Mc. crystal is employed as in the transmitter for 28-Mc. 'phone described in Chapter 7, the operating frequency of the crystal should be between 14,250 kc. and 14,850 kc.

The 6-meter band (50 to 54 Mc.) will be found, most of the time, to be usable only for ground-wave contacts from 25 to 125 miles depending upon the height of the transmitting location, the prevalence of lower-atmosphere bending, and the type of local terrain. If the location of the antenna would have to be in a valley where hills obstruct the view to other centers of population, operation on the 6-meter band will probably not be satisfactory. This statement also applies to operation on the 2-meter band. However, during the summer and fall of the year the 6-meter band will "open" occasionally for DX. When the 6-meter band is open

for this type of propagation, hills of reasonably low angle to the transmitting antenna will be found to offer little obstruction to contacts. See the periodicals *QST* and *CQ* for discussions of current sporadic-E propagation and predictions for the 6-meter band.

The 2-meter band (144 to 148 Mc.) will be found usable only for ground-wave and extended ground-wave propagation — distances from slightly over line-of-sight to perhaps twice line of sight. This type of operation will be found most reliable for local contacts. The 2-meter band is particularly effective for mobile operation from an automobile since the equipment and antenna may be made quite small and since operation on this band from the type of elevated locations available to automobile travel will be found to be most satisfactory.

Accessory Station Equipment In addition to the transmitter, the receiver, and the antenna of an amateur station, certain pieces of accessory monitoring equipment are required by FCC regulation. These equipments are: the frequency meter for all types of amateur operation, and the radiophone monitor for any type of radiotelephone operation. The latter piece of equipment is also called a "percentage-modulation meter."

A frequency meter is required for amateur station operation in order to insure that the station is not operating outside the assigned frequency band for the type of emission being employed (Chapter 1). The most satisfactory type of frequency meter will be found to be a factory-built model. This is true because the precision workmanship and careful calibration required in order to produce an equipment of sufficient stability and accuracy to satisfy the FCC is in all probability beyond the capabilities of the average newcomer. Certain excellent government surplus meters have been available in the past (Navy Model LM and Army type BC-221) and may be available for some time. Although these meters are expensive, they are a good investment and will give satisfaction for many years. Certain commercially-built meters especially for the amateur are also available in the same general price range as the surplus models.

Since the investment required for a factory-built frequency meter will probably be excessive at the outset of station operation, the FCC requirements can be met by the combination of a calibrated wavemeter, an accurately calibrated bandspread dial on the receiver, and a reference signal to "zero in" the bandset dial on the receiver to check its calibration. The reference signal for setting the receiver dial may be a harmonic of a local broadcast station, a harmonic of a 100-kc., 1000-kc., 5000-kc., or another standard crystal oscillator. It is necessary, however, that the reference signal come from a source separate from the transmitter frequency control. That is to say that the reference signal cannot come from the crystal in use to control the transmitter frequency, although another crystal in a separate oscillator may be used provided its calibrated frequency is sufficiently inside the desired amateur band that temperature drift and oscillator tuning cannot bring the crystal to the band edge. The wavemeter (inexpensive wavemeters of good quality are available from Millen Mfg. Co. and McMurdo Silver, Inc. to name two sources) should be coupled to the transmitter output circuit to make sure that the transmitter is operating on the correct harmonic of the frequency control crystal. The ordinary wavemeter is not sufficiently selective or accurate in

calibration to insure that the transmitter is inside the limits of the amateur band.

The modulation monitor for radiotelephone operation may consist of a cathode-ray oscilloscope operated in accordance with the instructions accompanying such an instrument, an instrument utilizing germanium crystals to rectify the carrier and the modulation envelope to afford indication on a d-c instrument such as the Sylvania modulation monitor, or the transmitter can be designed so that it is incapable of negative peak modulation in excess of 100 per cent through the use of some peak limiting system (see the *Radio Handbook*) with a simple carrier rectifier monitor such as described in Chapter 7 and illustrated in Chapter 5 Figure 51 used to monitor the audio quality and check for distortion. Further information on methods of checking modulation percentage are discussed in Chapter 10.

Operating Controls When carrying on two-way radio communication, the transmitter is thrown into operation during talking periods only and the receiver during listening periods only. The transmitter must be entirely "off the air" while listening. In most cases also, the antenna must be switched back and forth between transmitter and receiver.

It is desirable to carry on this switching operation between transmitter and receiver in the simplest and quickest possible manner, in order not to lose any part of a transmission and in order to be quick "on the come-back." Considerable delay enters the picture when several separate switches must be thrown in both transmitter and receiver. Amateur stations accordingly are arranged for one-operation switchover.

Simplified Switching Figure 111 shows the simplest scheme for obtaining single-operation switching in the station. Here, a 4-pole, double-throw switch is employed. This switch may be either a knife type, as shown in Figure 111—or it may be a rotary selector type mounted on the transmitter panel.

The two lower blades of this switch are connected together by means of a short jumper. The corresponding switch contacts on one side are connected in series with the B-minus line of the transmitter power supply, and those on the other side in series with the B-minus line of the receiver power supply. In its left-hand position, this switch turns the transmitter on; in its right-hand position, it turns the receiver on.

The two upper blades of the switch are connected to the station antenna. Consequently; when the switch is in its left-hand position, the antenna is connected to the transmitter. And when the switch is in its right-hand position, the antenna is connected to the receiver.

Relay Operation Figure 112 shows a very desirable system for pushbutton control of the station. With this scheme, the receiver is in operation (its power being on and the antenna connected) until the pushbutton is depressed. When the button is depressed; the re-

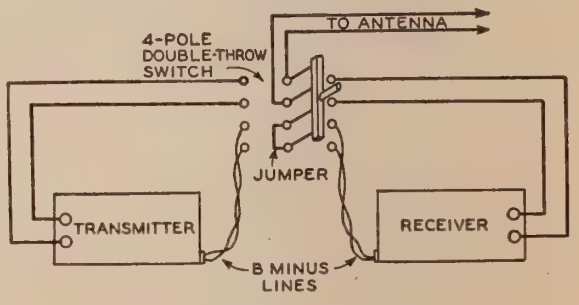


FIGURE 111

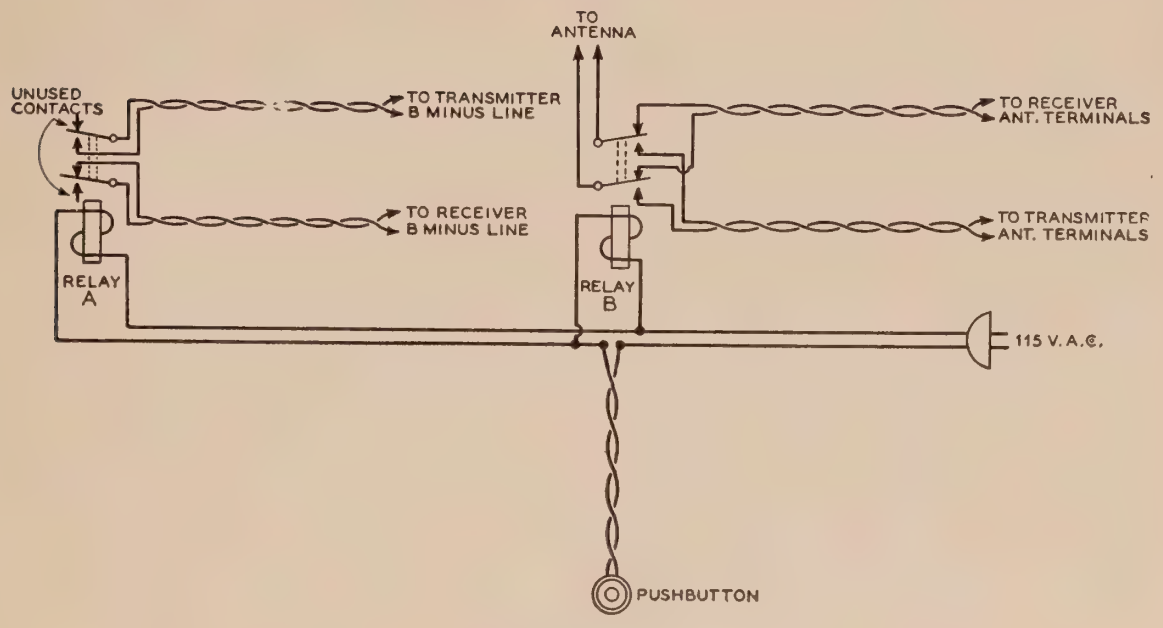


FIGURE 112

ceiver is switched off, the antenna transferred to the transmitter, and the transmitter power supply switched on. This system is favored for rapid changeover when using voice, and has received the familiar name of "push to talk."

This type of operation is obtained through the use of two 115-volt A.C.-operated relays. Both are double-pole, double-throw units, however Relay B is a special antenna changeover relay having good insulation and widely-separated contacts. When the push-button is not depressed; Relay A rests in the position shown in Figure 112, its lower contacts keeping the receiver power on and its upper contacts opening the transmitter power circuit. Also, Relay B connects the antenna to the receiver. When the button is depressed, however, current flows through the two relay coils and the relay armatures are attracted. In Relay A; the two upper contacts then are closed, switching-on the transmitter power, and the two lower contacts are opened, switching-off the receiver power. In Relay B; the blades then make contact with the two lower contacts, switching the antenna from the receiver to the transmitter. Figure 113 shows an alternative arrangement for effecting antenna changeover and receiver "live-dead" with one double-pole double-throw antenna changeover relay.

Arrangement of Station Equipment If the transmitter and receiver are small in size; these two units, together with the key and microphone, may be placed side by

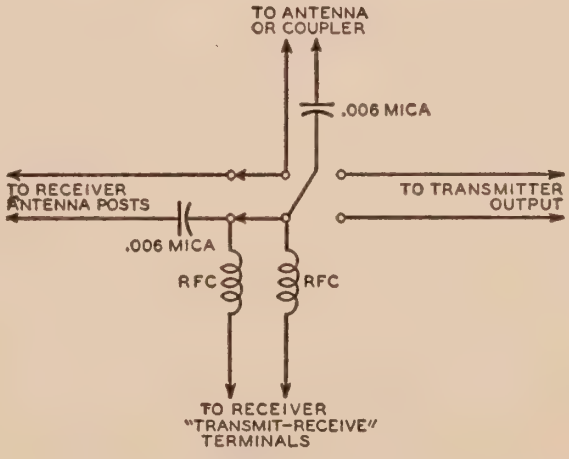


FIGURE 113

side on the operating table. The order in which they are placed will depend upon whether the operator is right or left-handed. The receiver and key require the most handling, consequently should be placed on the side corresponding to the operator's "best" hand.

The photo on page 51 shows this sort of table-top arrangement of a factory-built small transmitter and receiver, together with key, loudspeaker, headphones, and receiver plug-in coils. This shows how compactly a complete station may be arranged in a small space.

The apparatus should be so arranged within the operating room that trailing wires, whether connected to the power line or antenna, will be avoided. While it is desirable to place the station equipment as close as possible to the point at which the antenna wires enter the room, this is not absolutely imperative, since insulated wiring can be run to the antenna feeders, or a length of coaxial cable may be run to the antenna coupler.

Any cords or wiring to the 115-volt power line must be well insulated and should be of heavy duty size. Only wires and wiring approved by the Board of Fire Underwriters should be used. Old or frayed cords must not be employed. Keep all wiring concealed in order to prevent shock.

Where the high-voltage power supply unit is separate from the transmitter, do not install the power unit under a desk where the feet are likely to come into contact with it.

CHAPTER TEN

Operator's License Examination

Preliminary Notes The material given in this chapter is to aid you in your preparation for the amateur radio operator license examination. This material has been subdivided into the following main groups: (1) Operating Procedure, (2) Laws and Regulations, (3) Class B and C Technical, (4) Class A Technical. Candidates for either a Class B or Class C license should study sections 1, 2 and 3. Candidates for a Class A license must, in addition to being proficient in the first three parts, also thoroughly study part 4.

The questions given in this Chapter are not word for word those asked in the examinations but are paraphrases covering the scope of the examination. Technical questions are in bold-faced type.

Do not attempt to memorize each of the answers in a parrot-like manner. Even if you should pass your examination successfully by so doing, information obtained in this manner is not long retained and you will suffer in the long run. Study each question and answer thoughtfully and get a good idea of its meaning. Augment your study of this chapter with a more detailed study of the *Radio Handbook*. Understand each topic thoroughly before passing on to the next one.

1. Operating Procedure

1. How does one c. w. station call another?

By transmitting three times the call letters of the called station, the abbreviation DE (which means *from*), and the call letters of the calling station three times. This entire transmission is repeated three times, the last transmission being followed by the abbreviation AR (which signifies the end of the call and notifies that the calling station now awaits a reply). Example: W1ABC calls W9XYZ: W9XYZ W9XYZ W9XYZ de W1ABC W1ABC W1ABC (repeated three times) AR.

2. How does a c. w. station answer a call?

By transmitting three times the call letters of the station that called, the abbreviation DE, his own call letters three times, and the abbreviation K (which indicates that the other station should go ahead with its transmission). Example: W9XYZ answers W1ABC's call: W1ABC W1ABC W1ABC de W9XYZ W9XYZ W9XYZ K.

3. How does a c. w. station end a transmission?

Each single transmission in a group of transmissions comprising a conversation is concluded by transmitting the call letters of the other station, the abbreviation DE, and the call letters of the transmitting station followed by the abbreviation K. Example: W1ABC de W9XYZ K.

4. How does a c. w. station terminate *all* transmissions with a given station?

When all conversation is to be terminated, the station transmitting sends the call letters of the other station once, the abbreviation DE, his own call let-

ters once, and the abbreviation SK (which means all conversation with that particular station now is ended and there will be no further transmissions to that station). Example: W1ABC de W9XYZ SK.

5. How does a c. w. station transmit a general call, inviting conversation with *any* station choosing to reply to the call?

By transmitting three times the abbreviation CQ, the abbreviation DE, and the calling station's call letters three times. This entire transmission is repeated three times, the last transmission being followed by the abbreviation AR. Example: W1ABC sends out the general call: CQ CQ CQ de W1ABC W1ABC W1ABC (repeat three times) AR.

6. How does a c. w. station reply to a station sending out the general call CQ?

By calling the station in the usual manner (See Question 1).

7. How does a radiophone station call another?

In the same manner outlined for c. w. stations, except that the radiophone operator speaks directly and therefore has no use for abbreviations. However, the radiophone operator must give his geographical location. Example: "W1ABC W1ABC W1ABC. This is W9XYZ calling. W9XYZ at Streator, Illinois calling W1ABC and standing by." Instead of the term *standing by,* some radiophone operators prefer the service term *over* which indicates that the calling station is awaiting the reply.

8. How does one radiophone station answer another's call?

By speaking the call letters of the called station, the term *from,* his own call letters and the term *go ahead* or *over.* Example: "W1ABX from W9XYZ, over."

9. How does a radiophone station end a transmission in a series?

By speaking the call letters of the other station, the term *from,* his own call letters, and the term *go ahead;* or *over.* This is the same procedure given in answer 8.

10. How does a radiophone station end *all* transmissions with a given station?

By making an announcement to that effect, giving the call letters of the other station, identifying his own station, and terminating with an appropriate remark of leave taking. Example: " W1ABC, this is W9XYZ at Streator, Illinois, now signing off with you and saying good night."

11. How does a radiophone station send out the general call, inviting conversation with any station caring to answer?

By making a voice announcement to the effect that the calling station is *calling CQ.* This announcement must of course be followed by the calling station's call letters and geographical location. Example: "W1ABC at Boston Massachusetts, calling CQ" (repeated not more than three times) "W1ABC at Boston, Massachusetts, now standing by for a call."

12. How may a radiophone station identify his call letters more clearly?

The use of phonetic equivalents (key words) may be used for this purpose. For example: W1ABC may clarify his call letters when making any form of call in the following manner: W1ABC —W one Able Baker Charlie. Following is an approved phonetic alphabet:

In addition to the phonetics listed, some amateurs prefer to use others,

including the names of cities or countries.

A—ABLE	N—NAN
B—BAKER	O—OBOE
C—CHARLIE	P—PETER
D—DOG	Q—QUEEN
E—EASY	R—ROGER
F—FOX	S—SUGAR
G—GEORGE	T—TARE
H—HOW	U—UNCLE
I—ITEM	V—VICTOR
J—JIG	W—WILLIAM
K—KING	X—X-RAY
L—LOVE	Y—YOKE
M—MIKE	Z—ZEBRA

13. What is the accepted procedure regarding length of calls?

All calls, whether from c. w. or radiophone stations, and all replies, should be of the shortest possible length, in order to minimize interference with other stations and to reduce the time of transmissions.

14. What is meant by the abbreviation QRT?

The letters QRT mean "Cease sending." Followed by a question mark, this signal means "Shall I cease sending?" A list of Q signals may be found in Table 4 on Page 154.

15. What is meant by the abbreviation GA?

This abbreviation means *go ahead* and is for c. w. telegraph use. A full list of such abbreviations common to amateur radio may be found in Table 5, on Page 156.

16. What is the amateur distress signal, and under what circumstances is it transmitted?

The amateur distress signal is QRR. This signal must never be transmitted except in actual emergencies when the calling station has urgent messages relating to the safety of life or property in such disasters as hurricanes, earthquakes, etc., when normal communications have been disrupted and amateur radio has been placed at the service of the community.

17. How should a transmitter be tuned up?

All preliminary tuning operations must be made with the antenna disconnected from the transmitter. This minimizes interference with other communications. A suitable dummy antenna is connected to the transmitter during such initial tune-up periods.

18. In what frequency bands may the holder of a Class-A operator license operate a radiophone transmitter?

The holder of a class-A operator license may operate a radiophone transmitter in any amateur band in which radiophone operation is authorized. He has two bands (20 and 75 meters) available for his use that are not permitted to holders of class-B and class-C licenses.

19. May amateur stations transmit messages for a third party?

Yes. The amateur station may transmit a radiogram for a person who may not be an amateur operator. No material compensation, direct or indirect, may be accepted for this service, however.

20. May an amateur station transmit broadcasts?

No. No amateur station may transmit news, music, lectures, entertainment nor educational programs of any sort, at any time.

21. What is the normal method of carrying on amateur communications?

The normal method of communication is for one station to transmit at a time. The listening station has his turn to transmit. In *duplex* transmission, both stations talk back and forth, as in a normal telephone conversation.

In *break-in* operation, the listening station may interrupt the transmitting station at any time. Duplex operation is not permitted in most of the amateur bands, since it requires *two* operating frequencies; it is permitted, however, in the band 27.160 to 27.430 Mc. and on authorized amateur frequencies above 144 Mc.

22. How are entries made in the station log?

The law requires that every amateur station maintain a station log. This is a continuous record of operation. Each entry must show (1) call letters of the station called or communicated with, (2) date of communication, (3) time of calling or communication, (4) time of ending communications, and (5) signal strength reports. In addition, the signature of the operator, input power of the transmitter, frequency band used, and location of a portable station must be entered at least once or every time a change is made. Logs must be preserved for one year from the date of last entry. A copy of each message sent in message form must either be entered in the log or otherwise preserved for one year.

23. How do amateur stations report signal strength?

The amateur receiving station gives reports of signal strength, readability and tone (RST) to the transmitting station according to the following tables:

READABILITY (R)

1—Unreadable
2—Barely readable. Occasional words distinguishable
3—Readable but with difficulty
4—Readable with little difficulty
5—Perfectly readable

SIGNAL STRENGTH (S)

1—Very faint. Signal barely perceptible
2—Very weak signals
3—Weak signal
4—Fair signal
5—Fairly good signal
6—Good signal
7—Fairly strong signal
8—Strong signal
9—Very strong signal

TONE (T)

1—Extremely rough note
2—Very rough AC note
3—Rough AC note
4—Rather rough AC note
5—Modulated note
6—Modulated note but approaching whistle
7—Nearly DC note
8—Good DC note with slight ripple
9—Perfect unmodulated DC note

Note: Add an X after the appropriate tone number if the note appears to be crystal controlled.

If the signal is chirpy, add a C after appropriate tone number. Example: RST 468 indicates the received signal is readable with little interference, it is a good signal and an almost perfect note. By voice it is usually pronounced in full as "You are readability . . . Strength . . . Tone . . ."

Readability and strength are not necessarily synonomous. A station may be strength 7 but readability 2 due to powerful local interference.

24. What is the meaning of the special amateur abbreviation QST?

QST is the general call signal used by Headquarters station W1AW of the American Radio Relay League to call attention of all radio amateurs to a message to follow. This special signal has the significance of "CQ from the ARRL."

25. What is the meaning of the c. w. abbreviation "R"?

The abbreviation *R* signifies that an *entire* transmission has been received satisfactorily. It is equivalent to the

common speaking term *OK*. The abbreviation R should never be used when parts of a transmission have been received obscurely.

2. Laws and Regulations

1. Who must possess an amateur operator license?

All persons operating any form of amateur transmitter, on *any* radio frequency, must possess an amateur radio operator license. The operator of an amateur radiophone station may permit an unlicensed person to speak into his microphone, but the licensed operator must be in active control of the transmitter and its controls. An unlicensed person may not manipulate the key of a c. w. station under any circumstances.

2. How long is an amateur operator and station license valid?

Five years from date of issuance unless sooner modified, revoked, or suspended.

3. May a corporation hold an amateur radio license?

No. Amateur station licenses are granted only to licensed radio operators. However an amateur station license may be issued to a bona fide amateur radio society or association, with the name of a licensed member, acting as trustee, specifically noted.

4. May an amateur station be operated at locations other than the one appearing on its license?

Yes, provided the terms regarding portable operation are complied with. Briefly, these terms are: Prior to operating the equipment as a portable station at some other location, the operator must give written notice of the intended operation to the radio inspector of the district in which the operation is intended. The station may not be operated at such a portable location for more than 1 month without giving additional notice to the inspector. The total period of portable operation may not exceed 4 such 1-month periods.

A portable station must be so designated in all transmissions. For example, a c. w. station from the First call area and operated portable in the Second call area would identify itself thus: "W1ABC DN 2." A portable radiophone station in the same circumstance would identify itself: "W1ABC operating portable in New York City." When using radiophone the geographical location must be given.

5. What are the United States call areas?

See Table 2 on Page 15.

6. Are penalties provided for operating an amateur station without appropriate licenses?

Yes. Fines and imprisonment or both, are provided for each violation of operating an amateur station without necessary operator *and* station licenses. Both licenses are required.

7. What is the international distress signal?

SOS. Upon hearing this signal *all* stations must cease transmitting and stand by in order to prevent interference and to determine if they can render help to the party in distress.

8. May an amateur operator transfer his station or operator license, or the privilege granted thereunder, to another individual?

No. The amateur operator and station licenses are issued to individuals. No licensed amateur operator may transfer, lend, or assign his operator license to another individual. Nor may any holder of an amateur station license similarly transfer his station license to another individual. A visiting *licensed* amateur operator may be per-

mitted to operate any amateur station, however he must sign the station log indicating each transmission made by him.

9. What is the law regarding the availability of amateur licenses?

The amateur radio operator must have on his person at all times when operating amateur stations, his amateur operator license.

10. May an amateur station use call letters other than those assigned to that station?

No. An amateur radio station may not under any circumstances, use call letters other than those assigned by the Government expressly to that station.

11. How soon may an applicant for an amateur operator license be reexamined if he fails to pass his examination?

An applicant who fails examination for amateur operator privileges may not take another examination for such privileges within 30 days, except that this limitation shall not apply to an examination for class B operating privileges following an examination for class C privileges.

12. What steps must be taken by an amateur licensee who changes his address?

An application for modification of the amateur station license must be filed with the F.C.C. A modified license then will be issued to show the new address. If the station is to be operated prior to receipt of the modified license, a notification should be sent to the inspector in charge of the district in which the station is located regarding portable operation of the station at the new location (See Answer 4).

13. What is the regulation regarding renewal of amateur licenses?

An amateur station license may be renewed upon proper application filed not more than 120 days prior to date of expiration of such license and not later than the date of expiration. The applicant for renewal must show proof of use of his amateur station. In this connection, the applicant for renewal of an operators license must cite three contacts he has had in the last 6 months of the license term—*and these contacts must have been by way of telegraphy.*

14. May amateur stations be operated in motion, such as when installed in automobiles, airplanes or boats?

Yes, but only when authorized amateur frequencies higher than 25 megacycles are employed.

15. With whom may an amateur station communicate?

An amateur station may communicate with any other amateur station. Temporarily for test purposes or during emergencies, amateur stations may be employed also for communication with stations of other classes, such as commercial or government stations. The F. C. C. further says that "amateur stations may also make transmissions to points equipped only with receiving apparatus for the measurement of emissions, observation of transmission phenomena, radio control of remote objects, and similar purely experimental purposes."

16. What is the regulation regarding radiotelephone tests?

The transmission of music by an amateur station is forbidden. Single audio-frequency tones may be transmitted, however, for test purposes of short duration for the development and perfection of amateur radiotelephone equipment.

17. What is the legal maximum input power employed in amateur transmitters?

The d. c. plate power input to the final amplifier of an amateur transmitter must not exceed one kilowatt, except on frequencies within the 420-450-Mc. band where peak antenna power must not exceed 50 watts. Each amateur station operating with a plate power input in excess of 900 watts must have accurate means of measuring this input.

18. How well must the power supply of an amateur transmitter be filtered?

All amateur stations operated at frequencies lower than 144 Mc. must have adequately filtered power supplies in order to minimize power supply modulation and to avoid the emission of broad signals.

19. May harmonics be radiated by an amateur transmitter?

The law provides that any harmonic emission from an amateur transmitter must be suppressed as fully as the state of the art permits. Harmonics of this sort will create interference with other radio services.

20. What is the maximum modulation percentage permitted an amplitude-modulated amateur radiophone station?

100% or in no event in excess of its normal modulation capability. Overmodulation produces a broad interfering signal and increases adjacent channel interference without adding to the intelligibility of the signal.

21. Which stage of an amateur transmitter may be amplitude modulated?

Below 144 megacycles, only the final r. f. amplifier supplying the antenna may be amplitude modulated.

22. In which amateur bands may frequency modulation be employed?

FM signals may be transmitted by amateur stations in the following bands: 29 to 29.7, 52.5 to 54, 144 to 148, 235 to 240, 420 to 450, 1215 to 1295, 2300 to 2450, 3300 to 3500, 5250 to 5650, 10,000 to 10,500, and 21,000 to 22,000 megacycles.

23. What electrical measurements must the amateur operator be equipped to make in the normal operation of his transmitter?

In the normal operation of an amateur radio transmitter, the operator must be equipped to measure; (1) the operating carrier frequency of the transmitter, (2) the d. c. plate power input of the final amplifier supplying the antenna, and (3) the percentage of modulation, if the transmitter employs amplitude modulation. In addition, the operator must have some means of checking the r. f. harmonic output of his transmitter.

24. What is the law regarding amateur silent hours?

If the operation of an amateur station causes general interference to the reception of broadcast programs with receivers of good engineering design and this fact is made known to the amateur station licensee, the amateur station shall not be operated during the hours from 8 o'clock P.M. to 10:30 P.M., local time, and on Sunday for the additional period from 10:30 A.M. until 1 P.M., local time, upon the frequency or frequencies used when the interference is created.

25. What body regulates radio communications within the United States?

The Federal Communications Commission.

26. What happens if more than one complaint is received by the Commission relative to broadcast interference by an amateur station?

For a second citation of the same violation within a 12-month period, the amateur station will be required to maintain silent hours between 6 P.M. and 10:30 P.M., local time, until the Commission notifies the offending amateur station that full-time operation may be resumed. For a third citation of the same violation within a 12-month period, the offending amateur station will be restrained from operating from 8 A.M. to 12 midnight, local time "except for the purpose of transmitting a prearranged test to be observed by a monitoring station of the Commission to be designated in each particular case." The amateur operator who has been cited for several instances of the same offense within a single 12-month period is in grave danger of having his license suspended or revoked.

27. What is the regulation with respect to indecent or profane language?

The law provides that no licensed radio operator or other person shall transmit communications containing obscene, indecent, or profane words, language, or meaning.

28. Are false and deceptive transmissions prohibited?

Yes. Radio stations are warned by regulations not to transmit false or deceptive signals or communications by radio. No call letters not specifically assigned to the station by the Commission may be used in the operation of any radio station.

29. May one amateur station deliberately interfere with another?

No licensed radio operator shall willfully or maliciously interfere with or cause interference to any radio communication or signal. Penalty for violation is $500 for each day the offense occurrs as well as suspension of operator's license. The penalty for willful interference with distress communications is $10,000 fine and/or two years imprisonment and revocation of station license.

30. May an amateur station transmit a continuous unmodulated carrier wave?

An amateur station may transmit a plain c. w. carrier without any form of modulation or keying, only for short periods of time for experimental purposes or for authorized remote control purposes. A carrier wave of this type is designated Ao emission and is permitted only in the band 27.160 to 27.430 Mc. and on authorized amateur frequencies above 144 Mc.

31. How often must an amateur operator check the carrier frequency of his transmitter?

The law requires that the transmitter frequency be checked *regularly*. The regulations further provide that the means for such checking be independent of the frequency control equipment of the transmitter and that it possess sufficient accuracy to assure operation within the frequency band used.

32. What is the Government regulation regarding the willful damaging of radio apparatus?

No licensed radio operator shall willfully damage, or cause or permit to be damaged, any radio apparatus or installation in any licensed radio station.

33. What is the approved manner of answering notices of violations?

The regulation states: "Any licensee receiving official notice of a violation of the terms of the Communications Act of 1934, any legislative act, Executive Order, treaty to which the United States is a party, or the Rules and Regulations of the Federal Communications Commission, shall, within 3 days from such receipt, send a written answer direct to the Federal Com-

munications Commission at Washington, D. C., and a copy thereof to the office of the Commission originating the official notice, when the originating office is other than the office of the Commission in Washington, D. C.: Provided, however, that if an answer cannot be sent nor an acknowledgment made within such 3-day period by reason of illness or other unavoidable circumstances, acknowledgment and answer shall be made at the earliest practicable date with a satisfactory explanation of the delay. The answer to each notice shall be complete in itself and shall not be abbreviated by reference to other communications or answers to other notices. If the notice relates to some violation that may be due to the physical or electrical characteristics of transmitting apparatus, the answer shall state fully what steps, if any, are taken to prevent future violations, and if any new apparatus is to be installed, the date such apparatus was ordered, the name of the manufacturer, and promised date of delivery. If the notice of violation relates to some lack of attention or improper operation of the transmitter, the name of the operator in charge shall be given."

34. Must a mobile amateur station announce its operating location?

Yes. A portable amateur station operated while in motion must announce its geographical location and the fact that it is mobile at the time of the transmission. (See Answer 14).

35. May an amateur station operated in one frequency band communicate with an amateur station operating in another frequency band?

Yes. There is no regulation forbidding such cross-band communication.

36. May an amateur radiotelephone station communicate with an amateur c. w. telegraph station, and vice versa?

Yes. Phone-C. W. communication is permissible.

37. May the holder of a valid professional Radiotelephone or Radiotelegraph operator license operate an amateur radio station?

No. Government regulations specifically provide that an amateur station may be operated only by the holder of a valid *amateur* radio operator license.

38. What secrecy precautions must be observed by the amateur in handling messages?

No person to whom the contents of any radio message are known due to his transmitting or receiving it, shall divulge its contents to anyone other than the addressee, his agent or attorney, or other lawful authority.

39. What procedure is followed by the amateur during widespread emergencies?

When such an emergency is declared by the F. C. C., no transmission except those relating to relief work shall be made in the 1750-2050 and 3500-4000 kc. bands. The frequencies between 2025-2050, 3500-3525 and 3975-4000 kc. are reserved for emergency calling channels. After communication is established, a shift shall be made to other frequencies. Five-minute listening periods for the first five minutes of each hour shall be observed on the emergency calling channels as well as throughout the 1750-2050 and 3500-4000 kc. bands. These must be strictly observed unless engaged in handling official traffic of the highest priority.

3. Class B and C Technical

1. Name the basic units of electrical resistance, inductance, capacitance, current, electromotive force or

potential difference, power, energy, quantity, magnetomotive force, and frequency.

Basic Units: Resistance—ohms; Inductance — henry; Capacitance — farad; Current—ampere; Electromotive Force or Potential Difference—volt; Power—watt; Energy — joule; Quantity — coulomb; Magnetomotive Force — gilbert; Frequency—cycles per second.

2. Name the instruments normally used to measure:

(a) electric current
(b) potential difference
(c) power
(d) resistance
(e) frequency

(a) Ammeter
(b) Voltmeter
(c) Wattmeter
(d) Ohmmeter
(e) Frequency meter or wave meter

3. How may plate power input of an amplifier be determined when the plate voltage and plate current are known?

Plate power input may be determined by applying the power formula, P=EI (or W=EI), which means that the power equals the product of voltage in volts and the current in amperes.

4. Explain the purpose of using a centertap return connection on the secondary of a transmitting tube's filament transformer.

The effective (average) potential of the filament of a filament type tube with respect to the grid and plate is the same as the potential at the exact center of the filament. When using alternating current to heat the filament of the tube, there will be a small A.C. voltage impressed upon the grid unless the return is made to the exact center tap.

5. If the high-voltage secondary of a plate transformer was changed from a full-wave center-tapped to a bridge rectifier connection, what would be the relative voltage and current output ratings as compared to those for the full-wave center-tapped connection?

Changing from a full-wave center-tapped to a bridge rectifier would double the power supply output voltage and cut the permissible current in half.

6. Why is it advisable to use a plate power supply for the oscillator of a transmitter separate from the final amplifier plate power supply?

To prevent final amplifier power supply voltage variations, such as might be caused during keying or modulation, from being applied to the oscillator and causing undesired frequency modulation.

7. How does a swinging choke operate to improve the voltage regulation of a plate supply filter system?

Its inductance, and hence the voltage drop across it, decreases considerably with increasing load. The high inductance at low values of current prevents soaring of the output voltage at light loads.

8. Why is full-wave rectification generally preferable to half-wave rectification in a power supply?

A full-wave rectifier supplies twice as many pulses per second to the filter, for a given supply frequency, and therefore is easier to filter and provides better voltage regulation.

9. What are the relative advantages and disadvantages of mercury-vapor and high-vacuum rectifiers of equivalent filament ratings?

A mercury-vapor rectifier has lower internal resistance than the high-vacuum rectifier, and will therefore usually supply more voltage to the filter under load (for a given transformer

voltage). Because of its lower internal resistance, the mercury-vapor rectifier is more likely to be damaged from accidental overload or short circuiting. Mercury-vapor rectifiers sometimes cause "hash" to be generated because of transient oscillations set up each time the mercury vapor becomes ionized.

10. What are the principal output voltage ripple frequencies with half-wave and full-wave single-phase rectifiers, in terms of the a.c. supply frequency?

With a half-wave rectifier the principle output ripple frequency is equal to the supply-voltage frequency; with a full-wave rectifier it is equal to twice the supply-voltage frequency.

11. What is the principal reason for using a filter in a plate power supply system?

The filter in a power supply is used to smooth out the irregularities or "ripple" in the rectified alternating current, thus delivering a pure, unvarying voltage to the load circuit.

12. What would be a suitable type and the approximate capacitance of the filter condensers in a typical 1000-volt transmitter plate supply system?

With a choke-input, two-section filter the first condenser should be at least a 2-*u*fd. unit and the second a 4-*u*fd., if the power supply is to be used on a plate-modulated stage. With a radiotelegraph transmitter, the second condenser could be reduced to 2-*u*fd. The condensers preferably should be of the oil-filled paper type and rated at 1500 volts d.c. working voltage.

13. What would be the visible operating results of a short-circuited filter condenser in a plate power supply with an unfused primary circuit?

The first result would be a much more intense glow in mercury-vapor rectifiers or extremely high plate dissipation (as indicated by the plate becoming red hot) with high-vacuum type rectifier tubes.

14. Why should a fuse be used in the transformer primary circuit of a power supply system?

To prevent the damaging of power supply components in case of a short circuit in the power supply and to guard against the possibility of fire by preventing the power-supply components from becoming overheated in case of such a short circuit.

15. Why is a bleeder resistor connected across the output circuit of a high-voltage power supply system?

To improve the voltage regulation by keeping a small load on the power supply at all times when it is turned on and to provide a load which will discharge the filter condensers in cases where the power supply is turned off when no external load is connected.

16. What would happen if the primary of a 60-cycle power supply was connected to mains carrying continuous direct current?

The fuse would probably blow, if the primary were fused. Otherwise the primary or primaries of the transformers in the power supply would soon be burned out.

17. What is the principal advantage of a screen-grid type R.F. amplifier tube over a triode of equal output rating?

The screen-grid type tube requires no neutralization when used in a properly designed r.f. amplifier stage.

18. What tube rating indicates the maximum safe heat radiation capability of the anode of a vacuum tube?

The plate dissipation rating.

19. In the classification of tubes according to the number of elements, how many grids has each of the following types:

(a) diode
(b) triode
(c) tetrode
(d) pentode
(e) heptode?

(a) none
(b) one
(c) two
(d) three
(e) five

20. Describe the adjustment procedure for proper neutralization in a radio-frequency power amplifier using an r.f indicator coupled to the plate tank circuit.

First the plate voltage lead is disconnected. With excitation applied to the stage to be neutralized and the plate circuit tuned to resonance as shown by the indicator being used, the neutralizing adjustment should be varied until the neutralizing indicator shows zero output in the amplifier plate circuit. The plate and grid circuits should be kept tuned to resonance while the neutralizing adjustment is varied.

21. Why is it necessary to neutralize a triode radio-frequency power amplifier operating with input and output circuits tuned to the same frequency?

To prevent feedback of r.f. energy from the plate to grid through the plate-to-grid capacity of the tube. Feedback may cause the tube to self-oscillate.

22. What undesirable effects may result from operation of an unneutralized triode r.f. amplifier in a transmitter?

The stage may oscillate and thus cause spurious interfering signals to be generated. If the stage is modulated the spurious signals may change frequency and strength during modulation, thus causing interference over a wide band of frequencies. Improper neutralization of a modulated stage may also cause the signal to be badly distorted even though the stage does not self-oscillate at any time.

23. What undesirable effects result from frequency modulation of an amplitude-modulated carrier wave?

Spurious signals which occupy a wide band of frequencies and cause unnecessary interference may be transmitted.

24. What operating conditions would be favorable for harmonic generation in a radio-frequency doubler or frequency multiplying amplifier?

High bias, high excitation, and a sharply peaked exciting waveform are conducive to the generation of harmonics. A single-ended stage is a better generator of even harmonics than a push-pull stage. Likewise a high mu tube is a better frequency multiplier than a low mu tube, and a tetrode or pentode a better harmonic generator than a triode.

25. Where is link coupling applicable in an oscillator-amplifier type transmitter?

Between the plate tank of the oscillator and the grid tank of the amplifier (or between any two stages). Between the amplifier plate tank and the antenna tuning or matching tank.

26. What is the purpose of a Faraday (electrostatic shield) between the output circuit of an r.f. power amplifier and antenna coupling system?

To minimize electrostatic coupling to the antenna and thus prevent harmonics from reaching the antenna by this means.

27. What are the output circuit conditions for obtaining optimum power output from a radio-frequency amplifier-

The output tank circuit should have sufficient "Q" that maximum output occurs at the point of minimum plate current. The output tank should be operated at exact resonance. The amplifier should work into the proper value of non-reactive load.

28. In what stage of a transmitter is an amplifier of high harmonic output least desirable?

In the stage that feeds the antenna.

29. What are the relative plate current indications for resonance and off-resonance running of the plate tank circuit of a radio-frequency power amplifier?

When the stage is properly designed and loaded, or is running unloaded, resonance occurs at the point of minimum plate current. Off resonance the current is quite high.

30. What are the advantages of a push-pull r.f. power amplifier output stage as compared to a single-ended stage of the same power?

The push-pull stage is easier to neutralize at high frequencies, requires less "C" or tuning capacity in the plate tank circuit, and has much lower even harmonic output (2d, 4th, etc.).

31. In the diagram A31, what is the value of the bias voltage? What is the value of the bleeder resistance, R_2?

Bias voltage equals 3 volts (10 ma. or .01 amp. through 300 ohms). R_2 is equal to the plate voltage E divided by .005 (amp).

32. A certain 1750-kc. Y-cut quartz crystal has a positive temperature coefficient of 125 cycles per degree Centigrade and is started in operation at 40 degrees Centigrade. If the temperature-frequency characteristic is linear, what will the oscillation frequency be at a temperature of 60 degrees Centigrade?

1752.5 kc.

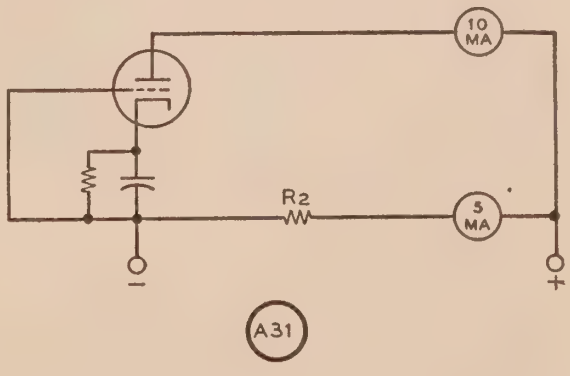
Note: A positive temperature coefficient means that the crystal drifts higher in frequency with an increase in temperature.

33. A 2000-kc. low-drift crystal having a negative temperature coefficient of 5 cycles per megacycle per degree Centigrade is started in operation at 40 degrees Centigrade. If the temperature-frequency characteristic is linear, what will the oscillation frequency be at a temperature of 60 degrees Centigrade?

1999.8 kc.

34. A low-drift crystal for the 3500-4000 kc. amateur band is guaranteed by a manufacturer to be calibrated to within 0.04% of its specified frequency. Desiring to operate as close to the lower band limit of 3500 kc. as safely as possible, for what whole-number kilocycle frequency should you order your crystal, allowing 1 kc. additional for variation from temperature and circuit constants?

3503 kc. The formula for opera-



tion close to the *low-frequency* end of the band is:

$$X = \frac{LF}{1-CT} + A$$

where X=crystal frequency desired
LF=low frequency limit of band
CT=calibration tolerance expressed as a decimal
A=allowance for circuit and temperature variations

35. For what frequency should you order your crystal for operation as close as safely possible to the upper limit of 4000 kc., with the same calibration accuracy and allowance given in Question 34?

3997 kc. The formula for operation close to the *high-frequency* end of the band is:

$$X = \frac{HF}{1+CT} - A$$

where HF=high frequency limit of band
All other symbols same as Question 34.

36. Draw a schematic diagram of a full-wave single-phase power supply using a center-tapped high-voltage secondary with a filter circuit for best regulation, showing a bleeder resistor providing two different output voltages and a method of suppressing "hash" interference from the mercury vapor rectifier tubes. Give the names of the component parts and approximate values of filter components suitable for either amateur rediotelephone or radiotelegraph operation.

See diagram A36.

37. Draw a simple schematic diagram of a plate-neutralized final r.f. stage using a triode tube coupled to a Hertzian antenna, showing the antenna system and a Faraday screen to reduce harmonic radiation.

See diagram A37.

38. Draw a simple schematic diagram of a half-wave rectifier with a filter which will furnish pure d.c. at highest voltage output, showing filter condensers of unequal capacitance connected in series with provision for equalizing the d.c. drop across the different condensers.

See diagram A38.

39. Draw a simple schematic diagram of a piezo-electric crystal-controlled oscillator using a pentode vacuum tube, indicating polarity of electrode supply voltages where externally connected.

See diagram A39.

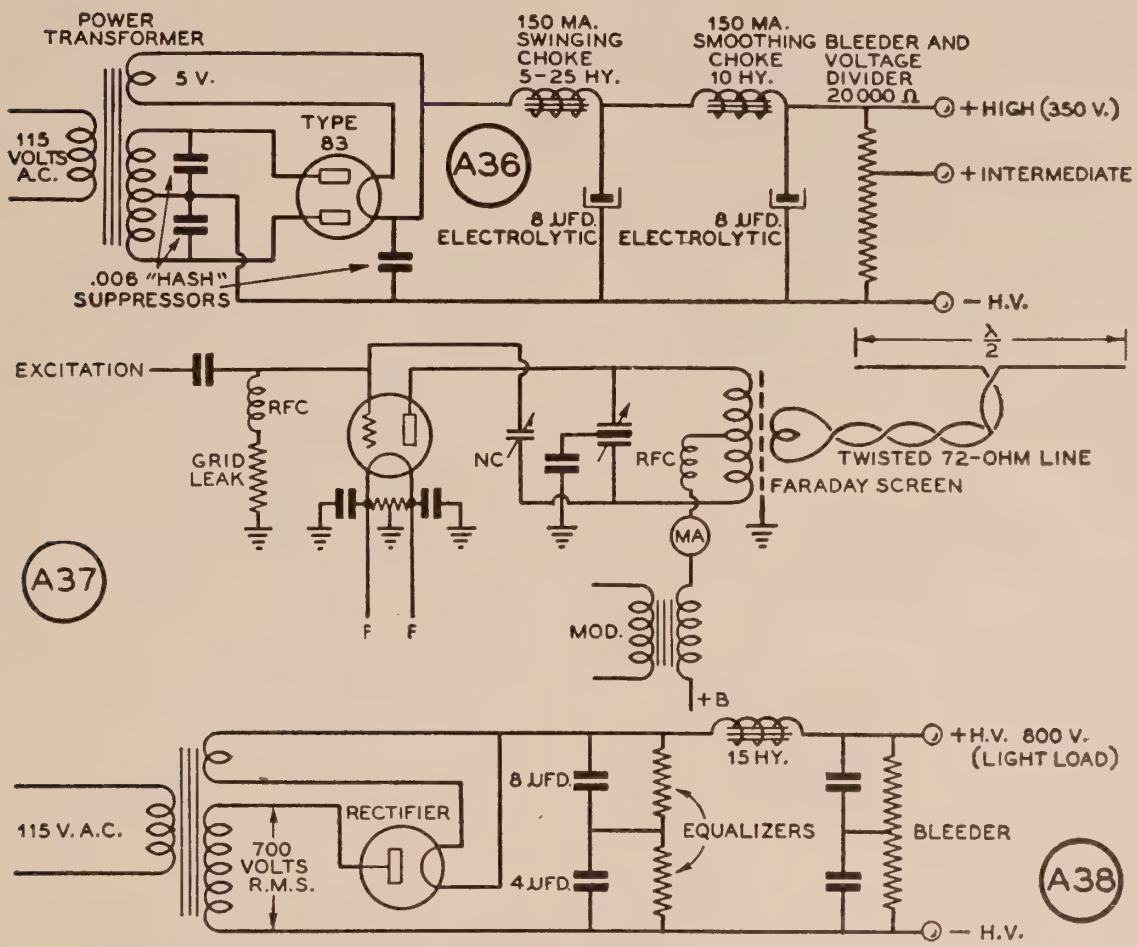
40. Draw a simple schematic diagram of two r.f. amplifier stages using triode tubes, showing the neutralizing circuits, link coupling between stages and between output and antenna system, and a keying connection in the negative high-voltage lead including a key-click filter.

See diagram A40.

41. Draw a schematic diagram of a filter for reducing amateur interference to broadcast reception consisting of a series-tuned circuit connected in shunt with the b.c. receiver input to bypass the interfering signal and a parallel-tuned (trap) circuit in series with the receiver input to reject the interfering signal?

See diagram A41.

42. Draw a schematic diagram of a pentode audio power amplifier stage with an output coupling transformer and load resistor, showing suitable instruments connected in the secondary for measurement of the audio-frequen-



cy voltage and current, and naming each component part.

See diagram A42.

43. What is the principal purpose of using door interlock switches on a transmitter?

Door interlock switches are used to protect the operator by opening the a.c. line voltage when the door is opened.

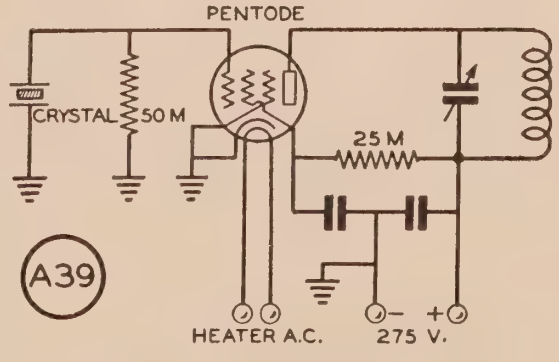
44. What is the usual means for protecting amateur station equipment from damage by charges of atmospheric electricity on the antenna system?

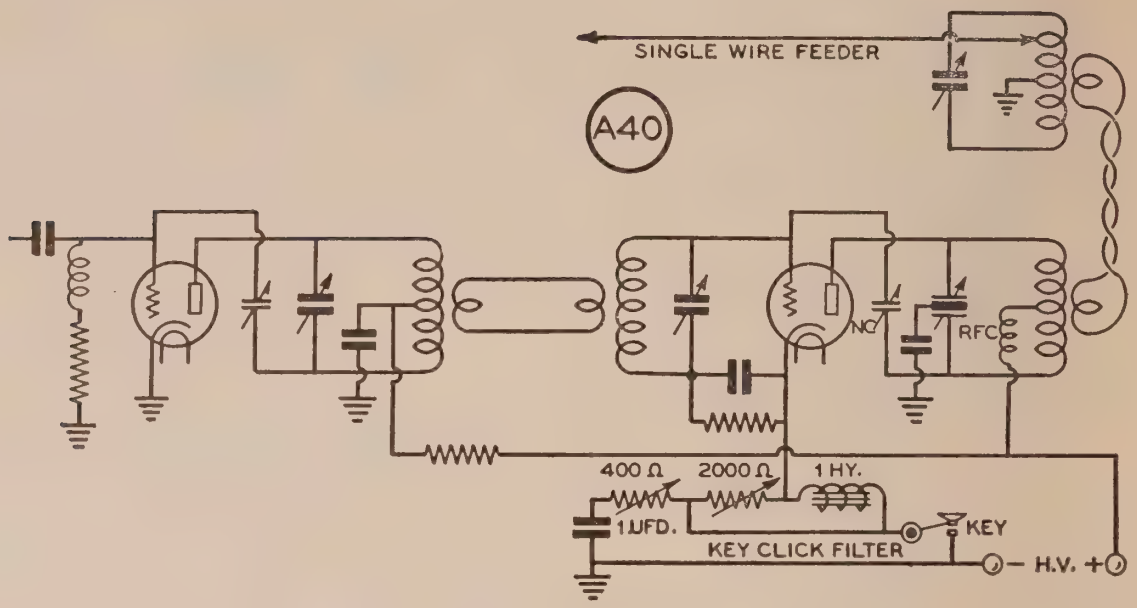
By grounding the feeders or a voltage node on the antenna through an r.f. choke or a high resistance non-inductive resistor. When not in use the antenna is grounded directly through a grounding switch.

45. What is a safe procedure for removing an unconscious person from contact with a high voltage circuit?

Turn off the voltage, or if impossible, pull him free by loose folds of clothing (if dry).

46. Using a frequency meter with a

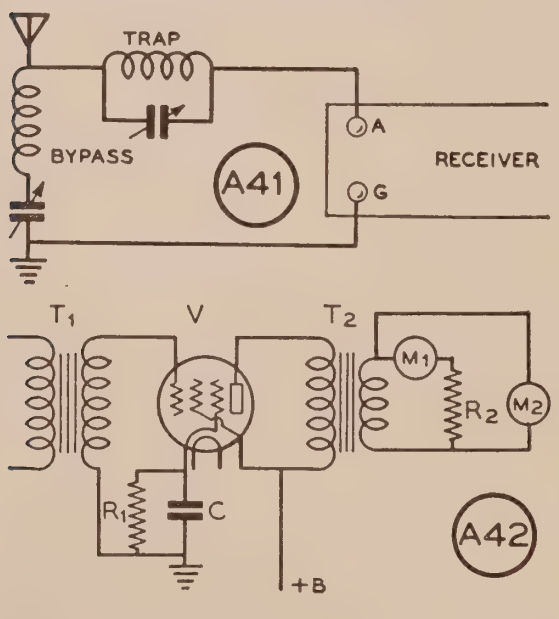




possible error of 0.75%, on what whole-number kilocycle frequency nearest the high-frequency end of the 3500-4000 kc. amateur band could a transmitter safely be set?

3970 kc. The formula for determining the indicated meter frequency close to the *high-frequency* end of the band is:

$$X = \frac{HF}{1+CT}$$



where X=indicated frequency
HF=high frequency limit of band
CT=possible frequency meter error as a decimal

47. Using a frequency meter with a possible error of 0.75%, on what whole-number kilocycle frequency nearest the low-frequency end of the 7000-7300 kc. amateur band could a transmitter safely be set?

7053 kc. The formula for determining the indicated meter frequency close to the *low-frequency* end of the band is:

$$X = \frac{LF}{1-CT}$$

where LF=low frequency limit of mand
All other symbols same as Question 46.

48. What radio messages have priority over all other communications?

Distress messages and communications relating thereto.

49. What is the penalty for willful or malicious interference with other radio communications?

Suspension of the license of the operator in the case of willful interference to ordinary communication; up to $10,000 and 2 years in prison in case of a distress message.

50. What is the F.C.C. rule regarding emission of unmodulated carriers by amateur stations?

Except for brief tests or adjustments, an amateur radio station shall not emit a carrier wave except for the purpose of communication.

51. On what amateur bands is portable operation permissible without prior notification to the inspector of the district in which such operation is contemplated.

Portable operation is not permitted on any frequency bands without prior notification to the inspector of the district in which such operation is contemplated.

52. When may third-party messages be handled between amateur stations of different countries?

When such exchange has been authorized by agreement between the countries involved. Third party traffic may be handled however, to persons in the U. S. military service stationed in foreign countries.

53. What period of each hour shall be used for making important initial calls when a state of communication emergency has been proclaimed by the F.C.C.?

The first five minutes of each hour.

54. When does a state of emergency affecting amateur communications become effective and when is it terminated?

The Commission shall declare that a state of general emergency exists, and the state of emergency shall be in effect until the Commission shall have declared such emergency to be terminated.

55. What amateur bands are affected and what frequencies are reserved for emergency calling when a state of communications emergency has been proclaimed by the F.C.C.?

The 1750-2050 kc. and the 3500-4000 kc. bands are affected. The frequencies within the bands 2025-2050 kc., 3500-3525 kc. and 3975-4000 kc. shall be reserved for emergency calling channels.

56. On what frequencies may a licensee holding Class B amateur privileges operate an amateur radiotelephone station?

On all amateur bands higher than 27 Mc. except for the 28.0-29-7 band in which radiotelephone operation is permitted only within the range 28.5-29.7 Mc.

57. What is the F.C.C. regulation regarding transmission of music by an amateur radio-telephone station for testing purposes?

It is unlawful regardless of purpose.

58. What is the highest modulation percentage of an amateur radiotelephone transmitter permitted by F.C.C. regulations and under what condition may it be employed?

100 per cent when the transmitter is capable of 100 per cent modulation without distortion.

59. What power input should an amateur station use for a particular communication when the maximum legal input is 1 kw?

The minimum power which will permit satisfactory communication with the desired station.

60. On what amateur bands is portable operation permitted only when prior notification has been given to the

F.C.C. inspector in charge of the district in which such operation is contemplated?

Prior notification to the inspector in charge of the district in which portable operation is contemplated, is required on *all* amateur bands.

61. On what amateur bands is adequately filtered d.c. plate power supply required for operation of an amateur transmitter?

On all amateur bands lower than 144 Mc.

62. On what amateur bands is adequately filtered d.c. plate power supply not required for operation of an amateur transmitter?

On all amateur bands higher than 144 Mc.

63. What is the maximum permissible plate power input to the final stage of an amateur transmitter and under what circumstances may it be used?

On frequencies within the band 420-430 Mc., no more than 50 watts input may be used. On all other amateur frequencies, not more than 1000 watts shall be used as plate power input to the transmitter stage feeding the antenna. If the input exceeds 900 watts however, adequate means for measuring the power input must be provided.

64. How would a short circuited turn of the coil affect the resonance frequency of a tuned circuit and why?

A shorted turn in the coil of a tuned circuit would raise the frequency of resonance since the inductance of the coil would be lowered.

65. What is meant by the harmonic of a fundamental frequency?

The harmonic of a frequency is an exact integral multiple of the fundamental frequency (2 times, 3 times, etc.)

66. What operating characteristics distinguish the electron-coupled type oscillator with regard to frequency stability?

The electron-coupled oscillator when properly designed has improved stability of frequency with respect to changes in supply voltages.

67. What circuit conditions will minimize the harmonic components in the output circuit of a given radio-frequency amplifier stage?

Operation of the stage as a push-pull amplifier, operation of the tubes into a circuit of high Q or C/L ratio, avoidance of unnecessarily large values of excitation and control grid bias.

68. Give the meanings of the following "Q" signals: QRK QRM QRT QRX QSA QSY QSZ.

QRK—The legibility of your signals is (1 to 5).

QRM—I am being interfered with.

QRT—Stop transmission.

QRX—Wait. I shall call you again at . . . (or immediately).

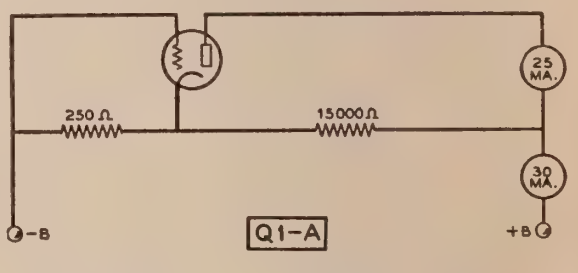
QSA—The strength of your signals is (1 to 5).

QSY—Shift to transmission on . . . kilocycles.

QSZ—Transmit each word or group twice.

4. Class A Technical

1. In diagram Q 1-A: (a) What is



the d.c. plate voltage? (b) What is the d.c. grid bias? (c) What is the supply voltage?

The d.c. plate voltage is 75 volts, the d.c. grid bias 7.5 volts, and the supply voltage 82.5 volts.

2. What undesirable effects may result from a self-oscillating buffer in a transmitter?

The frequency of the transmitted signal may be determined by the self-oscillating buffer, which might be oscillating outside the band. In other cases, the oscillating buffer may beat with the regular oscillator to produce several spurious frequencies in the output of the transmitter.

3. What type amplifier and class of operation is usually preferred for a frequency doubler?

A push-push type class C amplifier, using high bias and either pentode or beam tetrode tubes makes the best frequency doubler.

4. Why is it advisable to use a separate plate power supply for the oscillator of a multi-stage transmitter?

This form of isolation provides the best possible decoupling, and protects the oscillator from plate voltage changes at an a.f. rate as a result of modulation of a succeeding amplifier stage.

5. What is the most useful operating characteristic of a "push-push" type of amplifier?

A push-push amplifier makes an excellent frequency doubler because it is self-neutralized; no fundamental frequency output can appear in the plate tank, and there is no flattening of the excitation waveform as a result of degeneration.

6. What are the operating characteristics of the electron-coupled type oscillator with regard to frequency stability?

If the screen of the oscillator is supplied from a voltage divider on the plate supply and carefully adjusted to the correct value of screen voltage (as determined by experiment), then supply voltage fluctuations have negligible effect upon the frequency of oscillation.

7. What circuit conditions will minimize the harmonic components in the output of an r. f. power amplifier?

The amplifier should be of the push-pull type, have sufficient tank circuit "Q" when loaded, and use no more bias and excitation than is required for the class of operation desired. A split-stator tank condenser with the rotor of the condenser grounded will minimize harmonic content in a tank circuit.

8. What is the principal disadvantage of using a grid leak as the only source of bias in a class C radio frequency power amplifier?

Unless the amplifier tube(s) has a very high amplification factor, the tube may be damaged by excessive plate dissipation should the excitation voltage fail.

9. What are the relative merits of triodes and screen grid tubes as r.f. amplifiers?

Triodes are less expensive for a given power output, and generally permit slightly higher efficiency. However, they require neutralization except when used as frequency multipliers, and require appreciable excitation power when used as a class C amplifier or frequency doubler.

Screen grid tubes are more expensive, do not permit quite as high a maximum efficiency, and require special consideration when plate modulated. However, they do not require neutralization if designed for such use, and will permit good output and effi-

ciency either as a straight amplifier or frequency multiplier with a comparatively low value of excitation power.

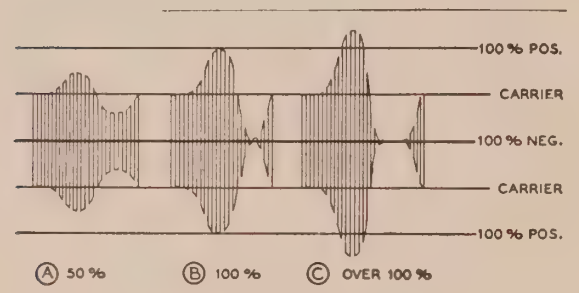
10. Show by a diagram the sinusoidal modulation envelope of an amplitude-modulated wave:

(a) Modulated approximately 75 per cent.

(b) Modulated approximately 100 per cent.

(c) Modulated substantially more than 100 per cent.

Refer to diagram Q10-A.



Q10-A

11. Draw a diagram of a plate-neutralized triode r.f. amplifier stage.

Refer to diagram A11-A.

12. Draw a diagram of a coupling system between two audio frequency stages, employing resistance elements.

Refer to diagram A12-A.

13. What are the principal reasons for using a choke-input type filter in a power supply using mercury vapor rectifier tubes?

To minimize the peak current through the rectifier tubes (for a given load current). Also, a choke input filter will provide better regulation.

14. Would mercury vapor or high vacuum type rectifier tubes of equivalent ratings be preferable for a power supply in which filament and plate voltages must be applied simultaneously? Give the reason for your choice.

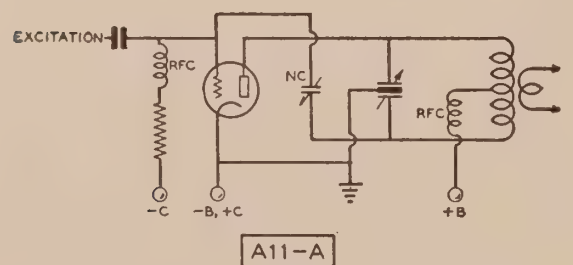
Except when run at greatly reduced ratings, mercury vapor rectifiers will be permanently damaged if plate voltage is applied before the cathode has reached full operating temperature. Therefore, high vacuum type rectifiers would be preferable in this case.

15. What visible operating characteristic distinguishes mercury vapor rectifiers?

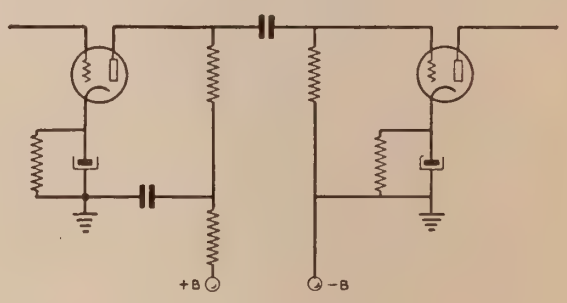
Mercury vapor rectifiers exhibit a characteristic bluish glow when operating normally under load.

16. Why are mercury vapor type rectifier tubes more critical as to observance of anode voltage rating than high vacuum type rectifiers?

Mercury vapor type rectifiers are subject to arc back and permanent damage when the inverse peak voltage exceeds a certain critical value.



A11-A



A12-A

17. What advantage has a push pull audio frequency amplifier over a single-tube class A amplifier of similar excitation requirement and equal power output?

A push pull amplifier has a lower value of even harmonic distortion. Also, the plate supply for the push pull stage need not be so well filtered.

18.What are the distinguishing operating characteristics of a class A type amplifier?

A class A amplifier is operated over the linear portion of the characteristic curve. The peak output and peak efficiency are both rather low. The average plate current remains constant. Usually the grid is operated entirely in the negative region, though sometimes in special circuits the grid is driven positive.

19. What improper operating conditions are indicated by upward or downward fluctuation of the plate current in a class A amplifier when signal voltage is applied to the grid? What correction should be made?

Assuming that the wave form of the exciting voltage is symmetrical, an upward shift in plate current indicates excessive negative grid bias and a downward shift in plate current indicates insufficient negative grid bias. The bias should be adjusted until the plate current does not fluctuate even when excessive audio input is applied to the grid, unless the plate dissipation is exceeded. In the latter case, the bias should be adjusted until the plate dissipation corresponds to the maximum rated value.

20. Why is bias voltage generally necessary on the grid of an audio amplifier tube, and what is the principal result of improper bias?

Negative bias ordinarily is required in order to permit the tube to operate over the desired portion of its characteristic curve. Improper bias reduces the maximum amount of output that is obtainable without objectional distortion.

21. What improper operating conditions are indicated by grid current flow in a conventional class A amplifier?

Grid current flow indicates either insufficient bias, excessive audio input, or a combination of both.

22. What is the principal advantage of a class B audio amplifier as compared to other types?

For a given pair of tubes, the most possible audio power output (with tolerable distortion) is obtainable with the tubes operating in class B. Thus a high order of output may be obtained with small tubes operating at moderate plate voltage.

23. How should the average plate current vary in a properly designed and operated amplitude-modulated radio-frequency power amplifier.

Assuming a constant carrier system, the average plate current should remain constant during modulation.

24. What are the notable efficiency and distortion characteristics of a class B modulator employing two triodes in push-pull?

A large amount of audio power may be obtained with tolerable distortion, and high average efficiency is obtained.

25. How do the excitation requirements of a class B modulator compare with those of a class A modulator having equal grid voltage swing?

As the grids of the class B modulator tubes are driven considerably positive on modulation peaks, an appreciable amount of driving power is required. Because of the non-linear

impedence offered by the grids, the driver stage must be capable of supplying the required power with good regulation.

As the grid or grids of the class A modulator are not driven positive, little power is required to drive the modulator to full output.

26. What would happen if the grid bias supply to a class B modulator were suddenly short-circuited?

The bias pack or battery would be damaged if left shorted for more than a very short time. The effect upon the modulator tubes would depend upon their amplification factor and plate resistance. Unless the tubes had a very high amplification factor or the plate voltage was low, the plate dissipation of the tubes would probably be exceeded as a result of the loss in bias.

27. What is the ratio of modulator audio power output to class C amplifier unmodulated plate power input in a plate modulation system:

(a) With a sinusoidal signal?

(b) With a two-tone signal equivalent to speech?

The ratio of 50 per cent with sinusoidal signal and 25 per cent with a signal equivalent to speech.

28. Define amplitude modulation.

Amplitude modulation is the process by which the peak r.f. voltage of the transmitted signal varies in amplitude in accordance with sound to be transmitted. Strictly speaking, the amplitude of the carrier wave does not vary; it is the mixing of the carrier and sidebands which produces the resulting r.f. voltage which varies in accordance with the modulation.

29. What are sideband frequencies?

Sideband frequencies are a product of modulation, and result when the radio frequency carrier wave and audio frequency signal to be transmitted are mixed. They are radio frequency oscillations having a frequency of the carrier frequency plus and minus each modulation frequency. Thus, when a 1000 kc. carrier is amplitude modulated by a 1000 cycle sine wave tone, the transmitted signal will contain the steady carrier at 1000 kc., a sideband at 999 kc., and a sideband at 1001 kc.

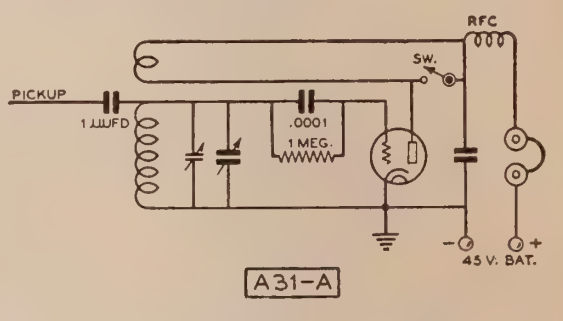
30. What radiotelephone transmitter operating deficiencies might be indicated by downward deflection of the antenna r.f. current meter during modulation of the final r.f. amplifier?

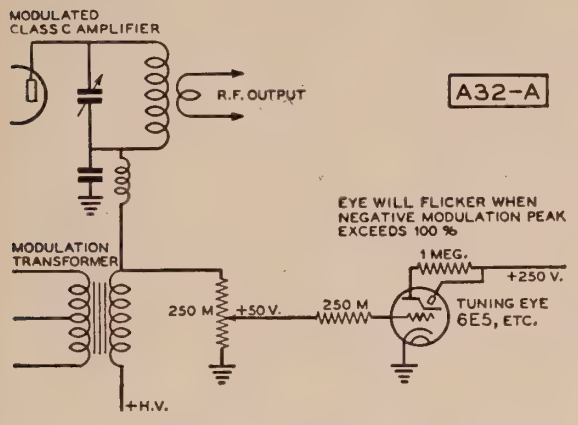
If a single ended modulator is used, it might indicate overloading of the modulator. If a class B modulator is used, and fed from the same power supply as the modulated stage, it might indicate poor regulation of the power supply; or, if separate power supplies are used, poor power line regulation. It may also be caused by one flat tube in a class B modulator.

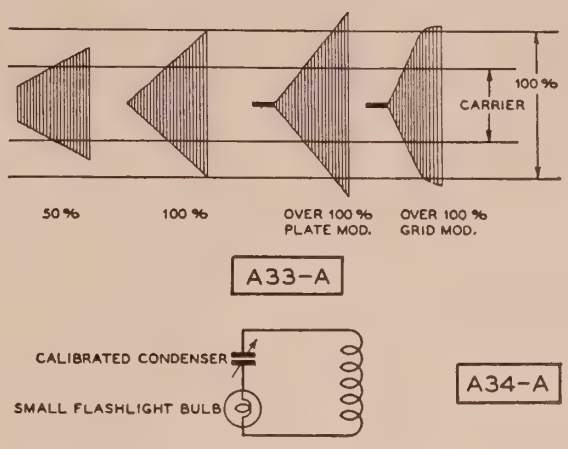
The following deficiencies in a plate modulated class C stage also will cause "downward modulation:" inadequate filament emission (flat tube), insufficient bias, insufficient excitation.

When grid bias modulation is used, downward modulation may be a result of insufficient antenna loading, insufficient bias, or excessive excitation.

31. Draw a diagram of a combination heterodyne frequency meter and monitor.







Refer to diagram A31-A. For use as a c.w. monitor or as a heterodyne frequency meter the switch SW is left open so that the circuit will oscillate. For use as a phone monitor it is closed, thus shorting the tickler and preventing oscillation.

32. Draw a simple schematic diagram of a peak modulation monitor which will indicate when 100 per cent modulation occurs or is exceeded

Refer to diagram A32-A.

33. Draw the trapezoidal type patterns showing 50 per cent modulation, 100 per cent modulation, and overmodulation as they would appear on the screen of a cathode ray oscilloscope properly connected to a phone transmitter.

Refer to diagram A33-A.

34. Draw a diagram of an absorption type frequency meter including a resonance indicator.

Refer to diagram A34-A.

35. Draw a simple schematic diagram of a radio frequency doubler stage driving a neutralized push pull power amplifier using triodes, showing the method of interstage coupling and indicating the relative resonance frequencies of the grid and plate circuits.

Refer to diagram A35-A.

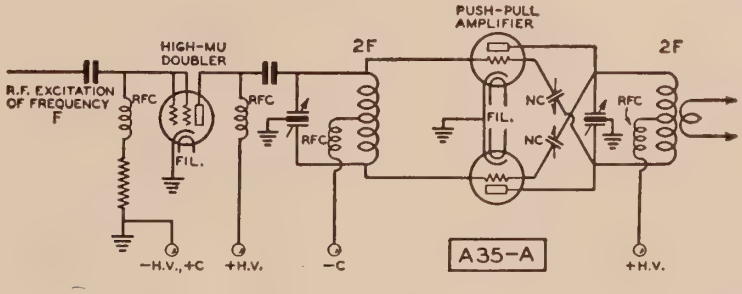
36. Draw a schematic diagram of a two-stage r.f. amplifier using screen grid tubes, showing a suitable method of interstage coupling.

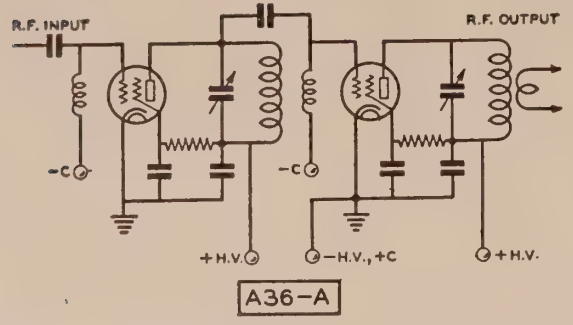
Refer to diagram A36-A.

37. Using a frequency meter with a possible error of 0.75 per cent, on what whole number kilocycle frequency nearest the low frequency end of the 14,000-14,400 kc. band could a transmitter safely be set?

14,106 kc. (See question 47, Section 3.)

38. Using a frequency meter with a





possible error of 0.75 per cent, on what whole number kilocycle frequency nearest the high frequency end of the 14,000-14,400 kc. band could a transmitter safely be set?

14,292 kc. (See question 46, Section 3.)

39. What particular precaution should be observed in using a battery operated heterodyne frequency meter?

Care should be taken that the batteries have not started to run down, as the filament and plate voltages will affect the calibration.

40. What particular precaution should be observed in using an absorption type frequency meter to check a self-excited oscillator?

The inductive coupling should be sufficiently loose that it does not appreciably affect the frequency of oscillation of the self-excited oscillator by altering the effective inductance of the oscillator tank coil.

41. What are the undesirable operation characteristics of a Y-cut crystal and what precautions should be taken when it is to be used for transmitter frequency control?

A Y-cut crystal has a large temperature coefficient of frequency, and therefore the frequency of a Y-cut crystal will change considerably with a change of temperature, especially when the operating frequency is in one of the higher frequency bands.

For a considerable change in temperature, the frequency change with temperature is not continuous; in other words the frequency will suddenly jump when the temperature passes through a certain critical temperature.

Some Y-cut crystals have a tendency to oscillate on either of two closely separated frequencies, depending upon the tuning of the circuit. Under certain conditions the crystal may jump from one frequency to the other, and be unsuitable for frequency control.

42. What is the purpose of using a quartz crystal in a transmitter?

A quartz crystal has an extremely high "Q", and therefore makes an excellent, highly stable frequency determing element.

44. What are the desirable characteristics of an A-cut crystal?

A properly ground A-cut crystal is highly active, will handle considerable power, and has a very low temperature coefficient at room temperatures normally encountered. The frequency change with temperature is not only very low, but continuous.

44. What particular physical characteristic distinguishes an X-cut crystal from Y- and A-cut crystals of the same frequency?

The X-cut crystal is appreciably thicker.

45. What would be the visible results of a short-circuited filter condenser in a plate power supply with high-vacuum rectifier tubes and an unfused primary circuit?

The rectifier anodes would immediately become red hot.

46. What precaution should be taken to protect filter condensers in series?

Across each condenser should be

placed a resistor of say 250,000 ohms, in order to equalize the d.c. voltage drop across them. The resistors should be within a few percent of the same value; therefore reasonably accurate resistors should be employed.

The condensers should have the same voltage rating, and if more than a very small a.c. component is impressed across the series circuit, the condensers should be of the same capacity.

47. Why is a full-wave rectifier preferable to half-wave rectifier?

A full-wave rectifier delivers output which is easier to filter. Better regulation is obtained. A smaller rectifier may be employed for a given load current when condenser input is employed, as the peak current will be only a small fraction as great as for a half-wave rectifier.

48. Two filter chokes have the same inductance, current and insulation voltage ratings, but one has twice the resistance of the other. Which would be preferable for use in a transmitter power supply and why?

The choke having the lower resistanceance would be preferable because there would be less d.c. voltage drop across it under load. This would result in higher output voltage and better regulation.

49. What constructional precaution should be taken to insure stable operation of a transmitter having one or more neutralized amplifier stages?

Avoidance of both magnetic and electrostatic coupling between tank circuits on the same frequency is necessary. On the lower frequencies this sometimes can be accomplished simply by physical isolation; but on the higher frequencies thorough shielding will be required.

50. Explain the purpose of using a center-tap return connection on the secondary of a transmitting tube's filament transformer.

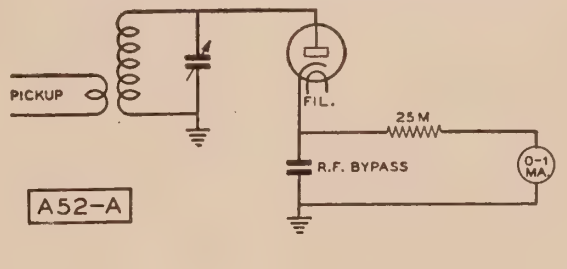
This connection minimizes modulation of the emitted carrier wave by the alternating current supply voltage when a tube having a directly heated cathode is employed. With the center tap connection the ripple will be doubled in frequency and, more important, greatly reduced.

51. On what amateur frequencies is frequency modulation of the emitted carrier permissible?

On the following bands: 27.160-27.430 Mc; 29.0-29.7 Mc.; 52.5-54.0 Mc.; and all higher frequency amateur bands.

52. Draw a schematic diagram of a simple device for checking carrier shift of a radiotelephone transmitter.

Refer to diagram A52-A.



CHAPTER ELEVEN

Questions and Answers

The questions in the preceding chapter are based on actual questions asked in the F.C.C. Amateur Radio Operator License examination. The general questions and answers which follow are included to assist in understanding principles underlying the operation of radio equipment.

Since it is impossible in a book of this size to provide a complete course in radio fundamentals, it is strongly recommended that reference be made to more detailed books on the subject, similar to those listed on the succeeding pages.

1. How is frequency in megacycles converted into wavelength in meters?

By dividing 300 by the frequency in megacycles.

2. What is reactance?

Reactance is the "a.c. resistance" offered by a coil or capacitor. Capacitive reactance is designated by the symbol Xc; inductive reactance by Xl.

3. What is impedance?

Impedance is the combined effect of reactance (X) and resistance (R) in an alternating current circuit. It is designated by the symbol Z and is the *vector sum* of resistance and reactance.

4. What is resonance?

Resonance is the condition resulting in an a. c. circuit when the inductive and capacitive reactances are equal. This occurs at one definite frequency. The one reactance cancels the other, no reactance therefore is left in the circuit, and the circuit is said to be "tuned" to the resonant frequency.

5. How is tuning accomplished in radio circuits?

By adjusting either the capacitive or inductive reactance of the circuit to bring about resonance. Usually, it is more practicable to vary the capacitive reactance.

6. Define the term "harmonic."

A harmonic is an integral multiple of a given frequency called the *fundamental.* It is equivalent to a musical overtone. The fundamental frequency is considered the 1st harmonic (although this term seldom is used), twice the fundamental is the 2nd harmonic, three times the fundamental is the 3rd harmonic, and so on.

7. In which direction do electrons flow through a conductor carrying current?

From the negative to the positive terminal.

8. What is the relationship between current (I), voltage (E), and resistance (R) in all electrical circuits?

$I=E/R \qquad R=E/I \qquad E=IR$

9. What is the relationship between current (I), voltage (E), and impedance (Z) in a. c. circuits?

$$I=E/Z \qquad Z=\frac{E}{I} \qquad E=IZ$$

10. How would you determine the power (in watts) if you knew the volt-

age (in volts) and the current (in amperes)?

By multiplying the current by the voltage. P=EI.

11. What is the relationship between current (I), power in watts (P), and resistance (R) in all electrical circuits?

$P=I^2R$

12. What is the relationship between power, voltage, and resistance in electrical circuits?

$P=E^2/R$.

13. What is meant by tube plate dissipation?

Plate dissipation, expressed in watts, is the difference between plate power input and output power, the difference being expended in the form of heating the plate.

14. What advantages over triodes do tetrodes, pentodes, and beam power tubes offer?

Tetrodes, pentodes, and beam power tubes require less grid signal voltage (excitation), generally give higher output for the same plate voltage, and usually do not require neutralization in r. f. amplifier circuits.

15. What are the essential differences between Class-A, Class-B, and Class-C amplifiers?

In the Class-A amplifier, the d. c. grid voltage (bias) is set at such a value that the tube operates along the straight portion of the tube characteristic curve. In the Class-B amplifier, the bias is adjusted to the point of plate current cut-off. In the Class-C amplifier, the bias is adjusted to a value greater than the cut-off value. Efficiency of the Class-A amplifier is relatively low, but the distortion of this amplifier likewise is low, hence it finds wide use in audio amplifiers. The Class-B amplifier has somewhat higher distortion, but in audio work it can handle larger powers. The Class-C amplifier has very high distortion, but very high efficiency. It accordingly finds wide use as a radio-frequency power amplifier, but is seldom employed for audio work.

16. What governs the frequency of a self-excited oscillator?

The inductance and capacitance values in the oscillator tank circuit. Tank capacitance is large compared to the shunting inter-electrode capacitance of the tube. Tank inductance likewise is large compared to stray inductance elsewhere in the oscillator circuit. Oscillator frequency also is dependent to some extent upon tube electrode voltages, especially plate voltage.

17. Explain the action of a quartz plate (crystal) in an oscillator circuit.

The quartz plate is a special form of electromechanical vibrator capable of oscillating at a radio-frequency rate. The nature of its vibration is such that either the thickness or another dimension of the plate alternately increases and decreases rapidly, the opposite faces of the plate becoming alternately positively and negatively electrified. This is another way of saying that the plate vibrates or oscillates.

The quartz plate is mounted between two flat metallic electrodes in contact with its opposite faces, and the entire assembly is connected between control grid and cathode of the oscillator tube.

When the plate tank is tuned to the natural frequency of the quartz plate, feedback voltage, transmitted by the grid-plate capacitance of the tube, sets the quartz plate into sustained oscillation. The small alternating voltages generated by the vibrating crystal are then applied between grid and cathode

of the tube, the latter serving to amplify these voltages.

The oscillation frequency of the plate depends upon its thickness and is very constant under a given set of operating conditions; such as ambient temperature, circuit arrangement, grid and plate voltages, etc.

Proper tuning of the circuit is indicated by minimum deflection (dip) of the plate milliammeter. In the absence of a milliammeter, a small radio pilot lamp connected to a 1-turn loop of insulated wire may be coupled to the plate tank coil and used as a tuning indicator. The lamp glows brightest when the tank is tuned to the crystal frequency. However the crystal oscillator circuit plate tank is usually detuned slightly on the low-capacity side of resonance to increase oscillator stability.

18. What are the common types of quartz crystals employed for r. f. oscillator control?

These are designated X-cut, Y-cut, and AT-cut according to the manner in which the plate has been cut from the natural quartz crystal.

19. How may the frequency of a crystal oscillator be closely stabilized?

By holding the quartz plate at a constant temperature. This is accomplished with thermostatically controlled crystal ovens.

20. Why is it necessary to neutralize a triode r. f. amplifier?

Because in a "straight-through" r. f. amplifier, grid and plate circuits are operated at the same frequency and the amplifier will tend to oscillate independently if not neutralized, similar to a tuned-plate, tuned-grid self-excited oscillator.

21. How is neutralization accomplished?

By means of small variable *neutralizing* capacitors which feed r. f. output voltage back to the amplifier grid circuit in the proper phase to cancel out oscillations.

22. Must screen-grid tubes, such as tetrodes and pentodes, be neutralized?

Usually, no. The high power sensitivity of some of these tubes however, especially the beam power types, make it impossible to avoid self-oscillation at the high frequencies and neutralization must be employed in such cases.

23. Why is it usually not necessary to neutralize a frequency multiplier?

Because in frequency multipliers (doublers, triplers, quadruplers, etc.), the plate circuit is tuned to a higher frequency than that of the grid signal and self-oscillation cannot easily occur.

24. What are the disadvantages of an unneutralized amplifier?

An unneutralized r. f. amplifier may radiate spurious signals because of self-oscillation.

25. Explain how to neutralize a radio-frequency amplifier.

The amplifier tube heaters are energized and r. f. excitation is delivered to the grid circuit of the amplifier in the usual manner. Plate (and screen) voltage is removed temporarily. If a tuned grid circuit is employed, it must be tuned to peak as indicated by maximum deflection of the r. f. amplifier grid milliammeter.

While observing the grid milliammeter reading, the amplifier plate tank condenser is tuned throughout its entire range. There should be no flicker of the grid current. Should the grid meter show a change or deflection as the plate tank is tuned, the neutralizing capacitor(s) must be re-set slightly and the plate tank again tuned. The operator must continue to make

small adjustments of the neutralizing capacitance until a setting is obtained where tuning the plate tank has no effect upon the reading of the grid milliammeter.

If a pushpull amplifier is employed with cross neutralization, *both* neutralization capacitors must be adjusted simultaneously.

If a grid milliameter is not employed in the amplifier circuit, a 2- or 6-volt radio pilot lamp, connected to a 1 or 2 turn coil of insulated wire and coupled to the amplifier plate tank, may be used as a somewhat less sensitive neutralizing indicator. This lamp will glow at some setting of the plate tank capacitor until complete neutralization is obtained, whereupon it will not glow at any setting.

The plate and screen voltages must not be applied to the r. f. amplifier until complete neutralization has been obtained.

26. What is the purpose of bypass capacitors in r. f. amplifiers?

Bypass capacitors complete r. f. paths, while blocking the passage of direct currents. Thus they serve to conduct r. f. currents around and out of a circuit component where the presence of both r. f. and d. c. would be undesirable. An example is the bypass capacitor connected in parallel with the cathode resistor in an amplifier. This capacitor provides a low-impedence path for r. f. currents thereby keeping them out of the cathode resistor, while the direct currents normally flowing through the resistor are unaffected.

27. Explain how grid bias is obtained in an amplifier stage by means of a grid resistor.

R. f. excitation voltage presented to the grid-cathode circuit of the amplifier results in the flow of a grid current, Ig, by virtue of rectification between grid and cathode. This current flows through the grid resistor Rg, thereby setting up a voltage drop (d. c.) equal to IgRg. This d. c. voltage has its negative polarity at the grid of the tube and its positive at cathode, the proper condition for d. c. grid bias. This system has the advantage of simplicity but the disadvantage that the amplifier tube runs without grid bias when excitation fails.

28. Explain how grid bias may be obtained by means of a cathode resistor.

The cathode resistor is connected between the tube cathode and B-minus (ground). Cathode current (total of plate and screen currents) pass through this resistor, Rk. A voltage drop, Ek (which is equal to the product RkIk) is set up across the cathode resistor. The polarity of this voltage is such that the cathode of the tube is positive and the grid is negative, the proper condition for negative grid bias.

Cathode bias has the disadvantage that the cathode voltage drop, Ek, must be subtracted from the plate voltage supply. The latter therefore must be larger than normal by the amount of the required bias voltage. Thus; if 2000 volts are required by the tube plate and 150 by the tube grid, the plate supply must be capable of furnishing a total of 2150 volts.

Cathode bias has the advantage that it is a form of fixed bias, serving to protect the amplifier tube in event of loss of excitation. As the plate current goes up, the bias also increases.

29. Describe undermodulation and overmodulation.

An a. m. carrier is undermodulated when the audio modulating voltage is insufficient to swing the carrier voltage between zero and twice the resting carrier value. This results in a carrier am-

plitude swing from somewhat more than zero to something under the twice-carrier value.

Overmodulation results when the audio modulating voltage is higher than the value required to swing the carrier voltage between zero and twice its resting amplitude. Here, the modulated carrier amplitude is some value greater than twice the unmodulated amplitude. Carrier cutoff periods result during the intervals when the modulating voltage would tend to swing the carrier amplitude to less than zero. This is because the carrier can have no smaller value than zero on the modulation down swing.

30. What are the disadvantages of undermodulation and overmodulation?

An undermodulated carrier does not make full use of the transmitter output power. A low-powered transmitter (small carrier output) completely modulated (100 percent) produces a more effective signal, especially at a distance, than a higher-powered transmitter which is undermodulated.

An overmodulated carrier produces a broad interfering signal. This is due chiefly to the cutoff periods resulting from the process which destroy momentarily the continuity of the r. f. carrier wave. Also, distortion often accompanies overmodulation, and pronounced broadcast interference is apt to result.

31. How does adding the audio voltage to the tube electrode voltage swing the carrier voltage?

The tube electrode voltage is d. c., while the modulating voltage is a. c. On one half-cycle of modulating voltage, the audio voltage adds to the d. c. voltage. On the next half-cycle, however, the audio cycle reverses and the modulating voltage bucks the d. c. The final result is that the tube electrode receives a *fluctuating* d. c. voltage and its r. f. output varies accordingly.

32. What are the chief characteristics of modulating systems?

(A) Grid bias modulation: A low-powered modulator may be employed to modulate a relatively high-powered r. f. amplifier. Usually, the audio system need be no more than an ordinary speech amplifier having 10 watts or so output power. This convenience is offset however, by the low plate efficiency of the bias-modulated amplifier—r. f. power output being approximately 33% of d. c. plate power input.

(B) Plate modulation: A relatively high-powered modulator stage is required (For 100% modulation, the modulator output watts must be equal to one-half the d. c. plate input watts of the r. f. amplifier). This is the most efficient system of amplitude modulation—r. f. power output being approximately 75% of the d. c. plate power input of the r. f. amplifier.

(C) Cathode modulation: Intermediate between grid-bias and plate modulation, as regards audio power requirement and operating characteristics of the r. f. amplifier. Various types of operation are possible. In a typical case, the audio output power of the modulator stage is 1/5 of the d. c. plate power input of the r. f. amplifier and the r. f. power output is approximately 55% of the d. c. plate power input of the r. f. amplifier.

33. In most radiotelephone transmitters, what manually-operated control governs the modulation percentage?

The gain control in the speech amplifier.

34. Why is a speech amplifier necessary in a radiotelephone transmitter?

In order to raise the low microphone output voltages to a level high enough to drive the modulator tube grid.

35. Should separate plate power supplies be employed for the r. f. and modulator stages of a radiotelephone transmitter?

Usually, yes. Unless a common supply has unusually good voltage regulation, its d. c. output voltage will change in value during modulation, resulting in improper operation of the transmitter.

36. Does the carrier frequency change during modulation?

No. In a properly operating a. m. radiotelephone transmitter, the carrier frequency is not shifted by the modulation process. When the frequency does change, undesired *frequency modulation* (F M) is said to occur.

37. What is the effect of modulating an oscillator stage in a transmitter?

In a modulated oscillator, the modulation process produces pronounced shifting of the carrier frequency. Because of this undesired frequency modulation, modulated oscillators are not permitted on any amateur frequencies except certain bands in the ultra-high frequency region.

38. Does the average value of the carrier voltage change during modulation?

No. In fact, the presence of a carrier shift (changing of the average carrier voltage during amplitude modulation) indicates faulty operation or adjustment of the transmitter.

39. What are the common causes of carrier shift?

(A) Poor voltage regulation in the r. f. amplifier power supply, (B) poor line voltage regulation, and (C) overmodulation.

40. Does the r. f. amplifier plate current change during modulation?

There should be very little, if any, perceptible movement of the d. c. plate milliammeter in the r. f. amplifier during modulation.

41. In which direction does the antenna current of a transmitter change during amplitude modulation?

Upward. An antenna ammeter will show an increase in indication (amounting to a 22½ percent change for 100% modulation), or a lamp coupled to the transmitter will glow more brightly during amplitude modulation.

42. How are parasitic oscillations eliminated in r. f. amplifier stages of a transmitter?

By connecting in the control grid lead (and often screen, as well) of the offending stage, either a parasitic suppressor resistor (50 or 100 ohms) or a small ultra-high-frequency r. f. choke. The latter usually consists of 3 to 5 turns of No. 14 bare wire air-wound about ½ inch in diameter, and spaced by the diameter of the wire. In some cases, it is necessary to employ a resistor and r. f. choke in parallel.

43. How does r. f. power output vary during normal amplitude modulation?

Because of the relationship between alternating voltage and power ($P=E^2/R$), the instantaneous *peak* power output of the r. f. amplifier during modulation is 4 times the normal (resting) carrier power output.

44. What is the result of insufficient spacing between plates in the plate tank tuning capacitor in a plate-modulated transmitter?

When the instantaneous plate voltage rises to twice its normal value during modulation peaks, the voltage rating of the capacitor will be exceeded and arcing will occur between capacitor plates.

CHAPTER TWELVE

F.C.C. Amateur Rules and Regulations

Pertinent rules of the Federal Communication Commission governing amateur radio are set forth in this chapter. In each case the Section number of the rule is given. A thorough study of these regulations is essential, not only to aid in passing the operator examination but to insure that the operation of the amateur station is in compliance with these regulations.

RULES GOVERNING AMATEUR RADIO SERVICE

DEFINITIONS

Sec. 12.1 ***Amateur service—***

The term "amateur service" means a radio service carried on by amateur stations.

Sec. 12.2 ***Amateur operator—***

The term "amateur operator" means a person interested in radio technique solely with a personal aim and without pecuniary interest, holding a valid license issued by the Federal Communcations Commission authorizing him to operate licensed amateur stations.

Sec. 12.3 ***Amateur station—***

The term "amateur station" means a station used by an amateur operator, and it embraces all radio transmitting apparatus at a particular location used for amateur service and operated under a single instrument of authorization.

Sec. 12.4 ***Amateur portable station—***

The term "amateur portable station" means an amateur station that is so constructed that it may conveniently be moved about from place to place for communication, but which is not operated while in motion.

Sec. 12.5 ***Amateur mobile station—***

The term "amateur mobile station" means an amateur station that is so constructed that it may conveniently be transferred to or from a mobile unit or from one such unit to another, and is ordinarily used while such mobile unit is in motion.

Sec. 12.6 ***Amateur radio communication—***

The term "amateur radio communication" means radio communication between amateur stations solely with a personal aim and without pecuniary interest.

LICENSES

Sec. 12.21 ***Eligibility for license—***

The following are eligible to apply for amateur operator license and privileges:

Class A. Any citizen of the United States who within five years prior to receipt of his application by the Commission, has held, for a period of a year or more, an amateur operator license issued by the Commission.

Class B. Any citizen of the United States.

Class C. Any citizen of the United States whose actual residence address, and amateur station are more than 125 miles airline distant from the nearest location at which examinations are held at intervals of not more than three

months for class B amateur operator license; or who is shown by physician's certificate to be unable to appear for examination because of protracted disability; or who is shown by certificate of the commanding officer to be in the armed forces of the United States at a military, naval or Coast Guard station and, for that reason, to be unable to appear for examination at the time and place designated by the Commission.

Sec. 12.22 ***Application for amateur operator license—***

Each application for amateur operator license shall comply with the Commission's Rules and Regulations and shall be made in writing on Form 610 (Application for amateur operator and/or station license). The application shall be filed with the district field office of the Commission if personal appearance is required for operator examination. If personal appearance is not required, the application shall be sent instead to the Commission, Washington 25, D. C. All applications for class C operating privileges shall be sent to the Commission, Washington 25, D.C.

Sec. 12.23 ***Classification of operating privileges—***

Amateur operating privileges are classified as follows:

Class A. All authorized amateur privileges.

Class B or C. All authorized amateur privileges except the use of type A-3 emission on the frequency bands 3900 to 4000 kc. and 14150 to 14250 kc.

Section 12.24 ***Scope of operator authority—***

Amateur operator licenses are valid only for the operation of licensed amateur stations; and, on a temporary basis, for the operation of experimental stations (except class 2 stations) in the experimental service licensed for operation exclusively on a frequency or frequencies above 450 mc. if such services are performed without compensation, direct or indirect, paid or promised.

Sec. 12.25 ***Availability of operator license—***

The original operator license of each operator shall be kept in the personal possession of the operator while operating an amateur station. When operating an amateur station at a fixed location however, the license may be posted in a conspicuous place in the room occupied by the operator. The license shall be available for inspection by any authorized government official whenever the operator is operating an amateur station and at other times upon request made by an authorized representative of the Commission, except when such license has been filed with application for modification or renewal thereof, or has been mutilated, lost, or destroyed, and application has been made for a duplicate license in accordance with section 12.26. No recognition shall be accorded to any photocopy of an operator license.

Sec. 12.26 ***Duplicate license—***

Any licensee applying for a duplicate license to replace an original which has been lost, mutilated, or destroyed, shall submit with the application the mutilated license or a statement setting forth the facts regarding the manner in which the original license was lost or destroyed. If, subsequent to receipt by the licensee of the duplicate license, the original license is found, either the duplicate or the original license shall be returned immediately to the Commission.

Sec. 12.27 ***Renewal of amateur operator license—***

An amateur operator license may be renewed upon proper application show-

ing that within the last six months of the license term the licensee has lawfully operated an amateur station or stations licensed by the Commission, and has thereby communicated by radio telegraphy with at least three other such amateur stations in the United States. The applicant shall qualify for a new license by examination if the requirements of this section are not fulfilled. Application for renewal of an amateur operator license shall be filed not more than 120 days prior to date of expiration of such license and not later than the date of expiration.

Sec. 12.28 ***Who may operate an amateur station—***

An amateur station may be operated only by a person holding a valid amateur operator license, and then only to the extent provided for by the class of privileges granted under the license. When an amateur station is used for telephony, the station licensee may permit any person to transmit by voice, provided that during such transmission call signals are announced as prescribed by section 12.82 and a duly licensed amateur operator maintains actual control over the emissions, including turning the carrier on and off for each transmission and signing the station off after communication with each station has been completed.

Sec. 12.29 ***License term—***

An amateur operator license is valid normally for a period of 5 years from the date of issuance of a new, renewed, or modified license.

Sec. 12.30 ***Order of suspension—***

No order of suspension of any operator's license shall take effect until 15 days notice in writing thereof, stating the cause for the proposed suspension, has been given to the operator, licensee who may make written application to the Commission at any time within said 15 days for a hearing upon such order. The notice to the operator licensee shall not be effective until actually received by him, and from that time he shall have 15 days in which to mail the said application. In the event that physical conditions prevent mailing of the application at the expiration of the 15-day period, the application shall then be mailed as soon as possible thereafter, accompanied by a satisfactory explanation of the delay. Upon receipt by the Commission of such application for hearing, said order of suspension shall be held in abeyance until the conclusion of the hearing which shall be conducted under such rules as the Commission shall deem appropriate. Upon the conclusion of said hearing the Commission may affirm, modify, or revoke said order of suspension.

Sec. 12.31 ***Proceedings—***

Proceedings for the suspension of an operator's license shall in all cases be initiated by the entry of an order of suspension. Respondent will be given notice thereof together with notice of his right to be heard and to contest the proceeding. The effective date of the suspension will not be specified in the original order but will be fixed by subsequent motion of the Commission in accordance with the conditions specified above. Notice of the effective date of suspension will be given respondent, who shall send his operator license to the office of the Commission in Washington, D. C., on or before the said effective date, or, if the effective date has passed at the time notice is received, the license shall be sent to the Commission forthwith.

EXAMINATIONS

Sec. 12.41 ***When examination is required—***

Examination is required for the issuance of a new amateur operator license, and for a change in class of operating privileges. Credit may be given, however, for certain elements of examination as provided in section 12.46.

Sec. 12.42 ***Elements of examination—***

The examination for amateur operator privileges comprises the following:

Element 1. Code test—Ability to send and receive, in plain language, messages in the International Morse Code at a speed of not less than 13 words per minute, free of omission or other error for a continuous period of at least 1 minute, during a test period of 5 minutes, counting 5 characters to the word, each numeral or punctuation mark counting as 2 characters.

Element 2. Amateur radio operation and apparatus, including telephone and telegraph.

Element 3. Provisions of treaties, statutes, and regulations affecting amateurs.

Element 4. Advanced amateur telephony.

Sec. 12.43 ***Elements required for various privileges—***

The examination for class A privileges will include all of the examination elements specified in section 12.42.

The examination for class B and class C privileges will include elements 1, 2, and 3 specified in section 12.42.

Sec. 12.44 ***Manner of conducting examination—***

The examinations for class A and class B privileges will be conducted by an authorized Commission employee or representative at locations and at times specified by the Commission.

Each examination for class C privileges will be conducted and supervised by not more than two volunteer examiners, whom the Commission may designate or permit the applicant to select; in the event the examiner for the code test is selected by the applicant, such examiner shall be the holder of an amateur operator license with class A or B operating privileges, or shall have held, within the 5 years prior to the date of the examination, a commercial radiotelegraph operator license issued by the Commission or within that time shall have been employed in the service of the United States as the operator of a manually operated radiotelegraph station. The examiner for the written test shall be at least twenty-one years of age.

Sec. 12.45 ***Additional examination for holders of class C operating privileges—***

The Commission may require a licensee holding class C operating privileges to appear for a class B examination at a location designated by the Commission. If the licensee fails to appear for the class B examination when directed to do so, or fails to pass such examination, the class C operator license previously issued shall be subject to cancellation and, upon cancellation, a new license will not be issued for the class C privileges.

Whenever the holder of class C amateur operating privileges changes his actual residence or station location to a location where he would not have been eligible to apply for class C privileges in the first instance, or whenever a new examining location is established in an area within which the holder of class C amateur operating privileges would not have been eligible because of such examining location, to

apply for class C privileges, such holder of class C privileges shall appear within 4 months thereafter at an examining location and time designated by the Commission and be examined for class B privileges. If, under such circumstance, the licensee fails to appear for the class B examination, or fails to pass such examination, the class C operator license previously issued shall be subject to cancellation and, upon cancellation, a new license will not be issued for the class C privileges.

Sec. 12.46 ***Examination credit—***

An applicant for class A privileges who holds an amateur operator license authorizing class B privileges will be required to pass only the examination element No. 4, advanced amateur telephony.

An applicant for class A privileges will be given credit for examination element 4 if within two years prior to the receipt of his application by the Commission he held class A privileges.

An applicant for any class of amateur privileges will be given credit for examination element 1 if within five years prior to the receipt of his application by the Commission he held a radiotelegraph first or second class operator license.

No examination credit for other classes of licenses or privileges shall be allowed.

A holder of an amateur operator license authorizing class C privileges will not thereby be accorded an abridged examination for either class B or class A privileges.

Sec. 12.47 ***Examination procedure—***

When taking an examination for amateur operator license, or for additional amateur operating privileges, the applicant shall write in longhand, by means of pen and ink. Diagrams shall be drawn either with pen and ink or with pencil; code tests shall be written or hand printed with either pen and ink or with pencil. Applicants unable to comply with these requirements, because of physical disability, may dictate their answers to examination questions, and if unable to draw required diagrams, may dictate a detailed description essentially equivalent. If the examination or any part thereof is dictated, the examiner shall certify the nature of the applicant's disability and the name and address of the person(s) taking and transcribing the applicant's dictation.

Sec. 12.48 ***Grading—***

Code tests are graded as "passed" or "failed," separately for sending and receiving tests. Failure to pass the required code test for either sending or receiving will terminate the examination.

Seventy-four per cent is the passing grade for written examinations. For the purpose of grading, elements 2 and 3 (required for class B and class C privileges) are considered to be a single examination and element 4 (required, in addition to the other elements, for class A privileges) is considered to be a separate examination.

Sec. 12.49 ***Eligibility for reexamination—***

An applicant who fails examination for amateur operator privileges may not take another examination for such privileges within 30 days, except that this limitation shall not apply to any examination for class B operating privileges following an examination for class C privileges.

AMATEUR RADIO STATIONS

Sec. 12.61 ***Eligibility for amateur station license—***

A license for an amateur station will be issued in response to proper appli-

cation therefor to a licensed amateur operator who has made a satisfactory showing of control of the transmitting station for which license is desired and of control of the specific premises upon which all of the station apparatus is to be located, at a designated fixed location. An amateur station license may be issued to an individual, not a licensed amateur operator (other than an alien or a representative of an alien or of a foreign government), who is in charge of a proposed amateur station located in approved public quarters and established for training purposes in connection with the armed forces of the United States, but not operated by the United States Government.

Sec. 12.62 ***Eligibility of corporations or organizations to hold license—***

An amateur station license will not be issued to a school, company, corporation, association, or other organization, nor for their use except that in the case of a bona fide amateur radio organization or society a station license may be issued to a licensed amateur operator as trustee for such society.

Sec. 12.63 ***Application for amateur station license—***

(a) Each application for an amateur station license shall comply with the Commission's Rules and Regulations and shall be made in writing, subscribed and verified on Form 610 (application for amateur operator and/or station license). Form 602 should be used where the applicant is in charge of a proposed amateur station located in approved public quarters and established for training purposes in connection with the armed forces of the United States, but not operated by the United States Government.

(b) One application and all papers incorporated therein and made a part thereof shall be submitted for each amateur station license and shall be filed with the district field office of the Commission if personal appearance is required for operator examination in connection with the application for station license. If personal appearance is not required, the station application shall be sent to the Commission, Washington 25, D. C.

Sec. 12.64 ***Location of station—***

Only one fixed location will be authorized and designated in the license for each amateur station. Unless remote control of the transmitting apparatus is authorized, such apparatus shall be operated by a duly licensed amateur operator present at the location of such apparatus.

The granting of authority to operate by remote control is contingent upon the filing of a proper application, supported by (1) a showing of the applicant's control of the control point, (2) a description of the means which will be employed to control emissions, (3) a description of the equipment and method of monitoring the emissions, and (4) a statement of the precautions which will be taken to prevent access by unauthorized persons to the premises on which the controlled transmitting apparatus is located.

Sec. 12.65 ***License period—***

The license for an amateur station is valid normally for a period of 5 years from the date of issuance of a new, renewed, or modified license.

Sec. 12.66 ***Authorized apparatus—***

An amateur station license authorizes the use under control of the licensee of all transmitting apparatus at the fixed location specified in the station license which is operated on any frequency, or frequencies allocated to the amateur service, and in addition authorizes the use, under control of

the licensee, of portable and mobile transmitting apparatus operated at other locations.

Sec. 12.67 ***Renewal of amateur station license—***

An amateur station license may be renewed upon proper application filed not more than 120 days prior to date of expiration of such license and not later than the date of expiration.

Sec. 12.68 ***Availability of station license—***

The original license of each amateur station or a photo-copy thereof shall be posted in a conspicuous place in the room occupied by the licensed operator while the station is being operated at a fixed location or shall be kept in his personal possession. When the station is operated at other than a fixed location, the original station license or a photo-copy thereof shall be kept in the personal possession of the station licensee (or a licensed representative) who shall be present at the station while it is being operated as a portable or mobile station. The original station license shall be available for inspection by any authorized government official at all times while the station is being operated and at other times upon request made by an authorized representative of the Commission, except when such license has been filed with application for modification or renewal thereof, or has been mutilated, lost, or destroyed, and application has been made for a duplicate license in accordance with section 12.26.

Sec. 12.69 ***Revocation of station license—***

Whenever the Commission shall institute a revocation proceeding against the holder of any radio station license under section 312 (a), it shall initiate said proceeding by serving upon said licensee an order of revocation effective not less than 15 days after written notice thereof is given the licensee. The order of revocation shall contain a statement of the grounds and reasons for such proposed revocation and a notice of the licensee's right to be heard by filing with the Commission a written request for hearing within 15 days after receipt of said order. Upon filing of such written request for hearing by said licensee, the order of revocation shall stand suspended and the Commission will set a time and place for hearing and shall give the licensee and other interested parties notice thereof. If no request for hearing on any order of revocation is made by the licensee against whom such an order is directed within the time hereinabove set forth, the order of revocation shall become final and effective, without further action of the Commission. When any order of revocation has become final, the person whose license has been revoked shall forthwith deliver the station license in question to the inspector in charge of the district in which the licensee resides.

Sec. 12.70 ***Modification of station license—***

(a) Whenever the Commission shall determine that public interest, convenience, and necessity would be served, or any treaty ratified by the United States will be more fully complied with, by the modification of any radio station license either for a limited time, or for the duration of the term thereof, it shall issue an order for such licensee to show cause why such license should not be modified.

(b) Such order to show cause shall contain a statement of the grounds and reasons for such proposed modification, and shall specify wherein the said license is required to be modified. It shall require the licensee against

whom it is directed, to be and appear at a place and time therein named, in no event to be less than 30 days from the date of receipt of the order to show cause why the proposed modification should not be made and the order of modification issued.

(c) If the licensee against whom the order to show cause is directed does not appear at the time and place provided in said order, a final order of modification shall issue forthwith.

Sec. 12.81 ***Assignment of call signal—***

(a) The calls of amateur stations will be assigned systematically by the Commission with the following exceptions:

(1) A specific unassigned call may be reassigned to the most recent holder thereof;

(2) A specific unassigned call may be assigned to a previous holder if not under license during the past five years;

(3) A specific unassigned call may be assigned to an amateur organization in memoriam to a deceased member and former holder thereof:

(4) A specific call may be temporarily assigned to a station connected with an event, or events, of general public interest.

(5) An unassigned two-letter call may be issued to a previous holder of a two-letter call.

Sec. 12.82 ***Transmissions of call signals—***

(a) An operator of an amateur station shall transmit the call of the station called or being worked and the call assigned the station which he is operating at the beginning and end of each transmission and at least once every 10 minutes during every transmission of more than 10 minutes duration. In the case of stations conducting an exchange of several transmissions in sequence, with each transmission less than 3 minutes duration, the call of the communicating stations need be transmitted only once every 10 minutes of operation as well as at the beginning and at the termination of the correspondence.

(b) In addition to complying with the requirements of paragraph (a) above, an operator of an amateur station operated as a portable or mobile station using radiotelegraphy shall transmit immediately after the call of such station, the fraction-bar character (DN) followed by the number of the amateur call area in which the portable or mobile amateur station is then being operated, as for example:

Example 1. Portable or mobile amateur station operating in the third amateur call area calls a fixed station: W1ABC W1ABC W1ABC DE W2DEF DN 3 W2DEF DN 3 W2DEF DN 3 AR.

Example 2: Fixed amateur station answers the portable or mobile amateur station: W2DEF W2DEF W2DEF DE W1ABC K.

Example 3. Portable or mobile amateur station calls a portable or mobile amateur station: W3GHI W3GHI W3GHI DE W4JKL DN4 W4JKL DN 4 W4JKL DN 4 AR.

When telephony is used, the call of the station shall be preceded by the words "this is" or the word "from" instead of the letters "de," followed by an announcement of the geographical location in which the portable or mobile station is being operated.

Example 4. Portable or mobile amateur radiotelephone station operating in the third call area calls a fixed amateur station: W1ABC W1ABC W1ABC "this is" or the word "from" W2DEF W2DEF W2DEF operating

portable (or mobile) three miles north of Bethesda, Maryland, over.

(c) When telephony is used, the transmission of call prescribed by subsections (a) and (b) of this section may be made by the person transmitting by voice in lieu of a duly licensed operator provided the licensed operator maintains the control required by section 12.28.

(d) When using telephony, phonetic aids to identify the call of the station may be employed.

(e) In addition to complying with the requirements of paragraph (a) above, an operator of an amateur station operated as a mobile station aboard a vessel of the high seas, or aboard an aircraft en route in an international voyage, shall, when the vessel or aircraft is outside the 10 call areas prescribed by the Commission in Section 12.81 (b), comply with the following calling procedure:

1. Mobile operating aboard a vessel.

i. When using telegraphy the amateur operator shall transmit immediately after the call of the station the fraction bar DN followed by the designator MM to indicate that the station is being operated as a mobile station aboard a vessel. In addition, the name of the vessel and its approximate geographical location shall be transmitted at the end of each transmission immediately prior to signing off. If the vessel does not have a name, the number of the vessel shall be transmitted in lieu of the name of the vessel.

ii. When using telephony the call of the station shall be preceded by the words "this is," or the word "from" followed by the words "maritime mobile," to indicate that the station is being operated as a mobile station aboard a vessel. In addition the name of the vessel and its approximate geographical location shall be transmitted at the end of each transmission immediately prior to signing off. If the vessel does not have a name, the number of the vessel shall be transmitted in lieu of the name of the vessel.

(2) Mobile operations aboard aircraft.

i. When using telegraphy the amateur operator shall transmit immediately after the call of the station the fraction bar DN followed by the designator AM to indicate that the station is being operated as a mobile station aboard an aircraft. In addition, the number of the aircraft and its approximate geographical location shall be transmitted at the end of each transmission immediately prior to signing off.

ii. When using telephony the call of the station shall be preceded by the words "this is," or the word "from" followed by the words "aeronautical mobile," to indicate that the station is being operated as a mobile station aboard an aircraft. In addition, the number of the aircraft and its approximate geographical location shall be transmitted at the end of each transmission immediately prior to signing off.

PORTABLE AND MOBILE STATIONS

Sec. 12.91 ***Requirements for portable and mobile operation—***

An amateur station may be operated as a portable station on any authorized amateur frequency and as a mobile station on any authorized amateur frequency above 25 Mc.

Sec. 12.92 ***Special provisions for portable stations—***

Prior to operating an amateur station as a portable station, the licensee shall give written notice to the inspec-

tor in charge of the district in which the portable operation is intended. This notice shall state the station call, the name of the licensee, the date or dates of proposed operation, and the contemplated portable station location as specifically as possible. An amateur station operated under the provisions of this section shall not be operated during any period exceeding 1 month without giving additional notice to the inspector in charge of the radio inspection district in which the station is intended to be further operated, nor for more than 4 consecutive periods of 1 month each at the same location.

Sec. 12.93 ***Special provisions for non-portable stations—***

The specific provisions of these rules relative to portable stations are not applicable to a non-portable station except that:

(a) The licensee of an amateur radio station may commence operating at a permanent location other than that specified in the station license if advance written notice is given to the inspector in charge of the district for which station license was issued, and to the inspector in charge of the district in which the operation (on frequencies below or above 25 Mc), is intended of the following particulars: the station call, the name of the licensee, and the proposed station location.

(b) The licensee of an amateur station who changes residence temporarily and moves his amateur station to a temporary location associated with his temporary residence, or the licensee-trustee of an amateur radio society which changes the normal location of its amateur station to a different and temporary location may use the station at the temporary location if the station is to remain there for a period of not more than 4 months and the following requirements are met:

(1) Advance notice in writing shall be given by the amateur station licensee or licensee-trustee to the Commission in Washington, D. C., and to the inspector in charge of the district in which the station is to be temporarily operated.

(2) Similar notice shall be given for each change in station location and for transfer of the station to the former permanent location, or to a new permanent location before the transmitting apparatus is operated.

(3) When the station is operated under the provisions of this section the calling procedure specified in section 12.82 shall be used, including transmissions of the fractional bar character when telegraphy is used followed by the number of the amateur call area in which the station is being operated. When telephony is used, an announcement shall be made of the geographical location in which the station is being operated.

USE OF AMATEUR STATIONS

Sec. 12.101 ***Points of communications—***

An amateur station may be used to communicate only with other amateur stations, except that in emergencies or for test purposes it may also be used temporarily for communication with other classes of stations licensed by the Commission, and with United States Government stations. Amateur stations may also be used to communicate with any radio station other than amateur which is authorized by the Commission to communicate with amateur stations. Amateur stations may be used also for transmitting signals, or communications, or energy, to receiving apparatus for the measurement of

emissions, temporary observation of transmission phenomena, radio control to remote objects, and for similar experimental purposes.

Sec. 12.102 ***No remuneration for use of station—***

An amateur station shall not be used to transmit or relay messages for hire, nor for communication for material compensation, direct or indirect, paid or promised.

Sec. 12.103 ***Broadcasting prohibited—***

An amateur station shall not be used for broadcasting any form of entertainment, nor for the simultaneous retransmission by automatic means of programs or signals emanating from any class of station other than amateur.

Sec. 12.104 ***Radiotelephone tests—***

The transmission of music by an amateur station is forbidden. However, a single audio-frequency tone may be transmitted for test purposes of short duration for the development and perfection of amateur radiotelephone equipment.

EQUIPMENT AND OPERATION

Sec. 12.131 ***Maximum authorized power—***

Except on frequencies within the band 420-450 Mc. (where peak antenna power shall not exceed 50 watts), each amateur transmitter may be operated with a power input not exceeding 1 kilowatt to the plate circuit of the final amplifier stage of an amplifier-oscillator transmitter or to the plate circuit of an oscillator transmitter. An amateur transmitter operating with a power input exceeding 900 watts to the plate circuit shall provide means for accurately measuring the plate power input to the vacuum tube or tubes supplying power to the antenna.

Sec. 12.132 ***Power supply to transmitter—***

The licensee of an amateur station using frequencies below 144 Mc. shall use adequately filtered direct-current plate power supply for the transmitting equipment to minimize modulation from this source.

Sec. 12.133 ***Purity and stability of emissions—***

Spurious radiation from an amateur station being operated with a carrier frequency below 144 Mc. shall be reduced or eliminated in accordance with good engineering practice. This spurious radiation shall not be of sufficient intensity to cause interference in receiving equipment of good engineering design including adequate selectivity characteristics, which is tuned to a frequency or frequencies outside the frequency band of emission normally required for the type of emission being employed by the amateur station. In the case of A-3 emission, the amateur transmitter shall not be modulated to the extent that interfering spurious radiation occurs, and in no case shall the emitted carrier wave be amplitude-modulated in excess of 100 percent. Means shall be employed to insure that the transmitter is not modulated in excess of its modulation capability for proper technical operation. For the purposes of this section a spurious radiation is any radiation from a transmitter which is outside the frequency band of emission normal for the type of transmission employed, including any component whose frequency is an integral multiple or submultiple of the carrier frequency (harmonics and subharmonics), spurious modulation products, key clicks and other transient effects, and parasitic oscillations. When using amplitude modulation on frequencies below 144 Mc., simultaneous frequency modulation is not permit-

ted and when using frequency modulation on frequencies below 144 Mc. simultaneous amplitude modulation is not permitted. The frequency of the emitted carrier wave shall be as constant as the state of the art permits.

Sec. 12.134 ***Modulation of carrier wave—***

Except for brief tests or adjustments, and except for operation in the band 27.160 to 27.430 Mc., an amateur radiotelephone station shall not emit a carrier wave on frequencies below 144 Mc. unless modulated for the purpose of communication.

Sec. 12.135 ***Frequency measurement and regular check—***

The licensee of an amateur station shall provide for measurement of the emitted carrier frequency or frequencies and shall establish procedure for making such measurement regularly. The measurement of the emitted carrier frequency or frequencies shall be made by means independent of the means used to control the radio frequency or frequencies generated by the transmitting apparatus and shall be of sufficient accuracy to assure operation within the amateur frequency band used.

Sec. 12.136 ***Logs—***

Each licensee of an amateur station shall keep an accurate log of station operation, including the following:

(a) The date and time of each transmission. (The date need only be entered once for each day's operation. The expression "time of each transmission" means the time of making a call and need not be repeated during the sequence of communications which immediately follows, however, an entry shall be made in the log when signing off so as to show the period during which communication was carried on.)

(b) The signature of each licensed operator who manipulates the key of a radiotelegraph transmitter or the signature of each licensed operator who operates a transmitter of any other type and the name of any person not holding an amateur operator license who transmits by voice over a radiotelephone transmitter. The signature of the operator need only be entered once in the log, in these cases when all transmissions are made by or under the supervision of the signatory operator, provided a statement to that effect also is entered. The signature of any other operator who operated the station shall be entered in the proper space for that operator's transmission.

(c) Call of the station called. (This entry need not be repeated for calls made to the same station during any sequence of communication, provided the time of signing off is given.)

(d) The input power to the oscillator, or to the final amplifier stage where an oscillator-amplifier transmitter is employed. (This need be entered only once, provided the input power is not changed.)

(e) The frequency band used. (This information need be entered only once in the log for all transmissions until there is a change in frequency to another amateur band.)

(f) The type of emission used. (This need be entered only once until there is a change in the type of emission.

(g) The location of the station (or the approximate geographical location of a mobile station) at the time of each transmission. (This need be entered only once provided the location of the station is not changed. However, suitable entry shall be made in the log upon changing the location. Where operating at other than a fixed location, the type and identity of the ve-

hicle or other mobile unit in which the station is operated shall be shown.)

(h) The message traffic handled. (If record communications are handled in regular message form, a copy of each message sent and received shall be entered in the log or retained on file at the station for at least 1 year.)

Sec. 12.137 ***Retention of logs—***

The log shall be preserved for a period of at least 1 year following the last date of entry. The copies of record communications and station log required by section 12.136 shall be available for inspection by authorized representatives of the Commission.

SPECIAL CONDITIONS

Sec. 12.151 ***Additional conditions to be observed by licensee—***

In all respects not specifically covered by these regulations each amateur station shall be operated in accordance with good engineering and good amateur practice.

Sec. 12.152 ***Restricted operation—***

(a) If the operation of an amateur station causes general interference to the reception of transmissions from stations operating in the domestic broadcast service when receivers of good engineering design including adequate selectivity characteristics are used to receive such transmissions and this fact is made known to the amateur station licensee, the amateur station shall not be operated during the hours from 8 o'clock p.m. to 10:30 p.m., local time, and on Sunday for the additional period from 10:30 a.m. until 1 p.m., local time, upon the frequency or frequencies used when the interference is created. (b) In general, such steps as may be necessary to minimize interference to stations operating in other services may be required after investigation by the Commission.

Sec. 12.153 ***Second notice of same violation—***

In every case where an amateur station licensee is cited within a period of twelve consecutive months for the second violation, the station licensee, if directed to do so by the Commission, shall not operate the station and shall not permit it to be operated from 6 p.m. to 10:30 p.m., local time, until written notice has been received authorizing the resumption of full-time operation. This notice will not be issued until the licensee has reported on the results of tests which he has conducted with at least two other amateur stations at hours other than 6 p.m. to 10:30 p.m., local time. Such tests are to be made for specific purposes of aiding the licensee in determining whether the emissions of the station are in accordance with the Commission's rules. The licensee shall report to the Commission the observations made by the cooperating amateur licensees in relation to the reported violations. This report shall include a statement as to the corrective measures taken to insure compliance with the rules.

Sec. 12.154 ***Third notice of same violation—***

In every case where an amateur station licensee is cited within a period of twelve consecutive months for the third violation, the station licensee if directed by the Commission, shall not operate the station and shall not permit it to be operated from 8 a.m. to 12 midnight, local time, except for the purposes of transmitting a prearranged test to be observed by a monitoring station of the Commission to be designated in each particular case. The station shall not be permitted to resume operation during those hours until the licensee is authorized by the Commission, following the test, to resume full-time operation. The results of the test and the

licensee's record shall be considered in determining the advisability of suspending the operator license or revoking the station license, or both.

Sec. 12.155 ***Answers to notices of violation—***

Under title III of the act—Any licensee receiving official notice of a violation of the terms of the Communications Act of 1934, any legislative act, Executive order, treaty to which the United States is a party, or the Rules and Regulations of the Federal Communications Commission, shall, within 3 days from such receipt, send a written answer direct to the Federal Communications Commission at Washington, D. C., and a copy thereof to the office of the Commission originating the official notice when the originating office is other than the office of the Commission in Washington, D. C.: Provided, however, that if an answer cannot be sent nor an acknowledgement made within such 3-day period by reason of illness or other unavoidable circumstances, acknowledgement and answer shall be made at the earliest practicable date with a satisfactory explanation of the delay. The answer to each notice shall be complete in itself and shall not be abbreviated by reference to other communications or answers to other notices. If the notice relates to some violation that may be due to the physical or electrical characteristics of transmitting apparatus, the answer shall state fully what steps, if any, are taken to prevent future violations, and if any new apparatus is to be installed, the date such apparatus was ordered, the name of the manufacturer, and promised date of delivery. If the notice of violation relates to some lack of attention or improper operation of the transmitter, the name of the operator in charge shall be given.

Sec. 12.156 ***Operation in emergencies—***

In the event of widespread emergency conditions affecting domestic communication facilities, the Commission may confer with representatives of the amateur service and others, and if deemed advisable, declare that a state of general communications emergency exists, designating the area or areas concerned (normally not exceeding 1,000 miles from center of the affected area), whereupon it shall be incumbent upon each amateur station in such area or areas to observe the following restrictions for the duration of such emergency:

(a) Transmissions, other than those relating to relief work or other emergency service, such as amateur station networks can provide, shall not be made within the 1750—2050 kc or 3500—4000 ks bands. Incidental calling, testing and working, including casual conversation or remarks not pertinent or necessary to constructive handling of the emergency situation shall be prohibited.

(b) Frequencies within the bands 2025—2050 kc, 3500—3525 kc and 3975—4000 kc shall be reserved for emergency calling channels, for initial calls from isolated stations or first calls concerning very important emergency relief matters or arrangements. All stations having occasion to use such channels shall change, as quickly as possible, to other frequencies for carrying on their communications.

(c) A 5-minute listening period for the first 5 minutes of each hour shall be uniformly observed for initial calls of major importance, both in the designated emergency calling channels and throughout the 1750—2050 kc and 3500—4000 kc bands. Only stations isolated or engaged in handling official

traffic of the highest priority may continue with transmissions in these listening periods. No replies to calls or resumption of routine traffic shall be made in the 5-minute listening periods.

(d) The Commission may designate certain amateur stations to assist in promulgation of its emergency announcement, to police the 1750—2050 kc and 3500—4000 kc bands and to warn non-complying stations observed to be operating therein. The operators of these observing stations shall report fully to the Commission the identity of any stations failing to comply, after notice, with any of the pertinent provisions of the section. Such designated stations will act in an advisory capacity when able to provide information on emergency circuits. Their policing authority shall be limited to the transmission of information from responsible official sources, and full reports of noncompliance which may serve as a basis for investigation and action under section 502 of the Communications Act. Such policing authority shall apply only to the 1750—2050 kc and 3500—4000 kc bands. Individual policing transmissions shall refer to this section of the rules by number (12.156) and shall specify briefly and concisely the date of the Commission's declaration and the area and nature of the emergency. Policing observer stations shall not enter into discussions with other stations beyond the furnishing of essential facts relative to the emergency.

(e) The special conditions imposed under this section will cease to apply only after the Commission shall have declared such emergency to be terminated.

Sec. 12.157 ***Obscenity, indecency, profanity—***

No licensed radio operator or other person shall transmit communications containing obscene, indecent, or profane words, language, or meaning.

Sec. 12.158 ***False signals—***

No licensed radio operator shall transmit false or deceptive signals or communications by radio, or any call letter or signal which has not been assigned by proper authority to the radio station he is operating.

Sec. 12.159 ***Unidentified communications—***

No licensed radio operator shall transmit unidentified radio communications or signals.

Sec. 12.160 ***Interference—***

No licensed radio operator shall willfully or maliciously interfere with or cause interference to any radio communication or signal.

Sec. 12.161 ***Damage to apparatus—***

No licensed radio operator shall willfully damage, or cause or permit to be damaged, any radio apparatus or installation in any licensed radio station.

Sec. 12.162 ***Fraudulent licenses—***

No licensed radio operator or other person shall obtain or attempt to obtain, or assist another to obtain or attempt to obtain, an operator license by fradulent means.

EXAMINING POINTS

Amateur operator examinations are given frequently, under announced schedules, at the Commission's office in Washington, D. C., and at each of its district offices. See Table 3, page 16.

Examinations are also given frequently, by appointment, at the Commission's offices at the following points:

Cleveland, Ohio	Tampa, Fla.
Savannah, Ga.	Juneau, Alaska
San Diego, Calif.	

Examinations are also given at greater intervals at the places named below, which are visited for that purpose by Commission examiners from the district offices for such locations. For current schedules, exact time, place, and other details, inquiry should be addressed to the office conducting examinations at the chosen point. See Table 3, page 16 for addresses of these offices.

Quarterly Examinations

Birmingham, Ala.
Charleston, W. Va.
Cincinnati, Ohio
Columbus, Ohio
Corpus Christi, Texas
Davenport, Iowa
Des Moines, Iowa
Fort Wayne, Indiana
Fresno, California
Grand Rapids, Mich.
Indianapolis, Indiana
Little Rock, Arkansas
Memphis, Tennessee
Milwaukee, Wisconsin
Nashville, Tennessee
Oklahoma City, Okla.
Omaha, Nebraska
Pittsburgh, Penn.
St. Louis, Missouri
Salt Lake City, Utah
San Antonio, Texas
Schenectady, N. Y.
Sioux Falls, S. D.
Syracuse, N. Y.
Tulsa, Oklahoma
Williamsport, Penn.
Winston-Salem, N. C.

Semi-annual Examinations

Albuquerque, N. M.
Amarillo, Texas
Bakersfield, Calif.
Bangor, Maine
Billings, Montana
Bismarck, N. D.
Boise, Idaho
Butte, Montana
Cumberland, Md.
El Paso, Texas
Hartford, Conn.
Hilo, T. H.
Jacksonville, Fla.
Klamath Falls, Ore.
Las Vegas, Nevada
Lihue, T. H.
Mobile, Alabama
Phoenix, Arizona
Portland, Maine
Reno, Nevada
Roanoke, Virginia
Salisbury, Maryland
Spokane, Washington
Tucson, Arizona
Wichita, Kansas
Wilmington, N. C.

TABLE 4

THE "Q" SIGNALS APPLICABLE TO AMATEUR OPERATION

Abbreviation	*Question*	*Answer*
QRA	What is the name of your station?	The name of my station is.....
QRB	How far approximately are you from my station?	The approximate distance between our stations is .....nautical miles (or .....kilometers).
QRG	Will you tell me my exact frequency (wavelength) in kc/s (or m)?	Your exact frequency (wavelength) is.. .....kc/s (or.....m).
QRH	Does my frequency (wavelength) vary?	Your frequency (wavelength) varies.
QRI	Is my note good?	Your note varies.
QRJ	Do you receive me badly? Are my signals weak?	I cannot receive you. Your signals are too weak.
QRK	Do you receive me well? Are my signals good?	I receive you well. Your signals are good.
QRL	Are you busy?	I am busy (or I am busy with.....). Please do not interfere.
QRM	Are you being interefered with?	I am being interfered with.
QRN	Are you troubled by atmospherics?	I am troubled by atmospherics.
QRO	Shall I increase power?	Increase power.
QRP	Shall I decrease power?	Decrease power.
QRQ	Shall I send faster?	Send faster (.....words per minute).
QRR	.....	Amateur "SOS" or distress call (U.S.A.). Use only in serious emergency.
QRS	Shall I send more slowly?	Send more slowly (.....words per minute).
QRT	Shall I stop sending?	Stop Sending.
QRU	Have you anything for me?	I have nothing for you.
QRV	Are you ready?	I am ready.
QRW	Shall I tell .....that you are calling him on..... kc/s or....m)?	Please tell ..... that I am calling him .....kc/s (or.....m.)
QRX	Shall I wait? When will you call me again?	Wait (or wait until I have finished communicating with.....). I will call you at.....o'clock (or immediately).

Abbreviation	*Question*	*Answer*
QRZ	Who is calling me?	You are being called by .....
QSA	What is the strength of my signals (1 to 5)?	The strength of your signals is..... (1 to 5).
QSB	Does the strength of my signals vary?	The strength of your signals varies.
QSD	Is my keying correct; are my signals distinct?	Your keying is incorrect; your signals are bad.
QSK	Shall I continue with the transmission of all my traffic; I can hear you through my signals?	Continue with the transmission of all your traffic; I will interrupt you if necessary.
QSL	Can you give me acknowledgment of receipt?	I give you acknowledgment of receipt.
QSM	Shall I repeat the last telegram I sent you?	Repeat the last telegram you have sent me.
QSO	Can you communicate with.....direct (or through the medium of.....)?	I can communicate with.....direct (or through the medium of.....).
QSP	Will you retransmit to..... free of charge?	I will retransmit to.....free of charge
QSU	Shall I send (or reply) on.....kc/s (or m) and/or on waves of Type A1, A2, A3, or B?	Send (or reply) on.....kc/s (or .....m) and/or on waves of Type A1, A2, A3, or B.
QSV	Shall I send a series of V V V.....?	Send a series of V V V .....
QSW	Will you send on.....kc/s (or .....m) and/or on waves of Type A1, A2, A3 or B?	I am going to send (or I will send) on .....kc/s (or.....m) and/or on waves of Type A1, A2, A3 or B.
QSX	Will you listen for.....(call sign) on .....kc/s (or .....m)?	I am listening for.....(call sign) on .....kc/s (or.....m).
QSY	Shall I change to transmission on..... kc/s (or .....m) without changing the type of wave? or Shall I change to transmission on another wave?	Change to transmission on.....kc/s (or.....m) without changing the type of wave. or Change to transmission on another wave.
QSZ	Shall I send each word or group twice?	Send each word or group twice.
QTA	Shall I cancel telegram No.....as if it had not been sent?	Cancel telegram No.....as if it had not been sent.
QTB	Do you agree with my number of words?	I do not agre with your number of words; I will repeat the first letter of each word and the first figure of each number.
QTC	How many telegrams have you to send?	I have ..... telegrams for you (or for.....).
QTH	What is your position in latitude and longitude (or by any other way of showing it)?	My position is..... latitude..... longitude (or by any other way of showing it).
QTR	What is the exact time?	The exact time is.....

TABLE 5

ABBREVIATIONS COMMONLY USED BY AMATEURS

ABT	About	LIL	Little
AGN	Again	LTR	Letter
AHD	Ahead	MA	Milliampere
ANR	Another	MC	Megacycle
ANI	Any	MG	Motor Generator
APRX	Approximately	MI	My
BC	Broadcast	MK	Make
BD	Bad	MSG	Message
B4	Before	MT	Empty
BI	By	ND	Nothing doing
BK	Break	NG	No good
BN	Been	NIL	Nothing
BT	But	NM	No more
BCUZ	Because	NR	Number
BTWN	Between	NW	Now
BIZ	Business	OB	Old Boy
C	See	OL	Old Lady
CLR	Clear	OM	Old Man
CN	Can	OP	Operator
CK	Check	OT	Old Timer
CKT	Circuit	OW	Old Woman
CMG	Coming	PLS	Please
CUD	Could	PSE	Please
CW	Continuous Wave	PX	Press
CUL	See you later	R	OK
CUAGN	See you again	RCD	Received
DE	From	RCVR	Receiver
DA	Day	RI	Radio Inspector
DNT	Don't	SA	Say
DINT	Did not	SEZ	Says
DH	Deadhead	SM	Some
DC	Direct current	SW	Short-wave
DX	Long distance	SIG	Signal
ES	And	SKED	Schedule
EZ	Easy	TFC	Traffic
FB	Fine business	TMW	Tomorrow
FM	From	TT	That
FM	Frequency Modulation	TKS	Thanks
FR	For	TNX	Thanks
FRQ	Frequency	U	You
FREQ	Frequency	UR	Your
GA	Go ahead	VT	Vacuum tube
GB	Good-bye	VY	Very
GM	Good morning	WA	Word after
GN	Good night	WB	Word before
GG	Going	WD	Would
GT	Got-Get	WK	Work
GND	Ground	WL	Will-would
HI (HA)	Laughter	WN	When
HM	Him	WT	What
HR	Here-Hear	WX	Weather
HV	Have	X	Interference
HW	How	XMTR	Transmitter
EEK	OK	YF	Wife
IC	I see	YL	Young lady
ICW	Interrupted CW	30	Finish-end
K	Go ahead	73	Best regards
LID	Poor operator	88	Love and kisses

BOOKS ON RADIO AND ALLIED SUBJECTS

A well-chosen if small library of good books is a necessity to any radioman. It is better to study carefully and thoroughly a few books than to be superficially acquainted with a number of them.

We recommend the texts listed below, which are available by mail from our Book Department at the prices stated.

ELEMENTARY THEORY

THE RADIO HANDBOOK, by Editors and Engineers, Ltd.

How-to-build-it descriptions of dozens of tested-and-tried types of transmitting, receiving and test equipment. Supplemented by basic electrical and radio theory in the simplest possible language. Illustrated with hundreds of diagrams and large photographs showing details of construction. Has the most complete tube tables to be found in any book. Clothbound. Over 700 pages. Book No. RH. $2.50 at your dealer's (in U.S.) Postpaid direct from us $2.75 in U.S. elsewhere, $3.00.

FUNDAMENTALS OF RADIO, by F. E. Terman

A first book and also a good refresher for all radio students and workers. This text has been widely used in civilian and military classes. Requires no knowledge of complex mathematics. Contents: The Fundamental Components of a Radio System. Circuit Elements. Resonant Circuits and Circuit Analysis. Fundamental Properties of Vacuum Tubes. Vacuum-tube Amplifiers. Power Amplifiers. Vacuum-tube Oscillators. Modulation. Vacuum-tube Detectors. Sources of Power for Operating Vacuum Tubes. Radio Transmitters. Radio Receivers. Propagation of Radio Waves—Antennas. Radio Aids to Navigation. Television. Acoustics. Book No. TF10. 458 pages. $4.00*

PRINCIPLES OF RADIO, by Keith Henney

A basic course in radio which may readily be comprehended by high-school or trade-school students and may be used in independent home study. Well illustrated. Contents: Fundamentals. Direct-Current Circuits. Electrical Meters and Measurements. Production of Current. Magnetism and Electromagnetism. Inductance. Capacitance. Properties of Alternating-Current Circuits. Resonance. Properties of Coils and Condensers. Vacuum Tubes. The Tube as an Amplifier. Rectifiers and Power Supply Apparatus. Audio Amplifiers. Detection. Receiver Systems. Oscillators. Transmitters. Antennas and Electromagnetic Radiation. Frequency Modulation. Ultra-High Frequency Phenomena. Electronic Instruments. Book No. HP20. 534 pages. $3.75*

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A student wishing a sound grounding in electrical fundamentals before undertaking the study of communications, and the communications student or worker requiring a reference book or refresher course in electricity will find Timbie admirably suited to the need. The few mathematical applications, which never go beyond simple algebra, are completely explained in this book. A summary follows each chapter, and well chosen problems are offered to test the student's learning and to give practice in applying electrical principles. Book No. TB20. 603 pages. $3.75.

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Basic fundamentals of electricity, radio, television and sound especially adapted to home instruction; a minimum of mathematics; contains many self-review questions. Covers every branch of radio including broadcasting, servicing, aviation, marine, police, military, public address, and electronics applications. Book No. GP60. 972 pages. $5.00*

ELEMENTS OF RADIO, by A. & W. Marcus

An extensive course prepared for those without previous training in mathematics or physics; particularly recommended for premilitary training; one of the best for this purpose. Particularly good for home study, to obtain basic goundwork for jobs in radio industry. Book No. ME80. 699 pages. $4.00*

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Covers basic communications more completely than most books intended for beginners, but is perhaps a bit difficult for those with no previous technical training; practical; relatively easy to follow. Intended for industrial training, armed forces, etc.; follows N.A.B. outline. A leader in this field. Book No. EF80. 727 pages. $5.00*

INTERMEDIATE AND ADVANCED THEORY

RADIO ENGINEERING, by F. E. Terman

Probably the most popular foundation engineering textbook for all serious radio courses and libraries. Thoroughly revised. Contents: The Elements of a System of Radio Communication. Circuit Constants. Properties of Resonant Circuits. Fundamental Properties of Vacuum Tubes. Vacuum-tube Amplifiers. Power Amplifiers. Vacuum-tube Oscillators. Modulation. Vacuum-tube Detectors. Sources of Power for Operating Vacuum Tubes. Radio Transmitters. Radio Receivers. Propagation of Waves. Antennas. Radio Aids to Navigation. Television. Sound and Sound Equipment. Book No. TE10. 813 pages. $6.00*

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Using clear language and the absolute minimum of elementary mathematics, this book covers atomic and electronic theory, vacuum- and gaseous-tube circuit operation, photocells, cathode ray tubes, x-rays, television tubes, the electron microscope, electronic production of light, tube circuits for power, communication, and industrial control applications, and electronic measurements. Book No. FE10. 358 pages. $4.00*

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ELECTRON TUBES AND INDUSTRIAL ELECTRONICS

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ELECTRONICS IN INDUSTRY, by G. M. Chute

A non-technical treatment of the subject for the industrial technician or executive. Electron-tube applications in numerous industries are described. Concise, meaty explanations are augmented by well-chosen diagrams. Book No. CE10. 403 pages. $5.00*

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Industrial electronics explained especially for the electrical worker who must install and maintain electronic equipment in factories, offices, and homes. The electrician, factory or office executive, and salesman may gain a quick understanding of basic electronic principles and of related equipment from a study of this book. Book No. CC10. 247 pages. $2.75*

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TRANSMISSION LINES, ANTENNAS, AND WAVE GUIDES, by King, Mimno, and Wing

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OPERATING—COMMERCIAL

PRACTICAL RADIO COMMUNICATION, by A. R. Nilson and J. L. Hornung

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This book gives 20 lessons on sending and receiving radio code signals and messages. It contains selected practice material for use with code practice sets (construction of which is described) and gives a resume of rules and regulations governing radio operators. Book No. NC11. 174 pages. $2.75*

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MODERN RADIO SERVICING, by A. A. Ghirardi

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PRINCIPLES AND PRACTICE OF RADIO SERVICING, by H. J. Hicks

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